The Engineering Review.

Edited by

C. EDGAR ALLEN, A.M.I.E.E., Etc.

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The Mining Exhibition at Olympia.

OLYMPIA is once more about to be requisitioned for industrial purposes, as, on the 11th of July, there will be opened, by the Right Hon. Lord Strathcona, G C.M.G., High Commissioner for Canada, a mining exhibition organised under the direction of Mr. H. Greville Montgomery, M.P. This exhibition, which is to run until July 31st, promises to be the most representative of its kind ever held, as the leading manufacturers in this country, and several from abroad, have taken the matter up in a thoroughgoing manner, with the result that a unique display of up-to-date mining appliances will be on view.

Practically every branch of mining is represented, the exhibits including collections from New South Wales, Western Australia, India, Rhodesia, South Africa, Russia, and other places abroad. No efforts have been spared by the management to secure a large attendance, and visits have been arranged from the South Wales Institute of Engineers, North of England Institute of Mining and Mechanical Engineers, National Association of Colliery Managers, Midland Counties Institution of Engineers, Manchester Geological and Mining Society, Mining and Geological Institute of India, and the German Mining Engineers of Silesia. The members of these societies are men practically interested in the industry, and their attendance will go far to ensure the success of the exhibition from the business standpoint.

The general public, too, will find much to interest and educate them, as the galleries and annexe are to be given over to practical demonstrations of the operations involved in diamond, gold, coal, and tin mining and quarrying.

The exhibits themselves we shall deal with in the next number; meantime, at the exhibition itself, all friends and supporters of THE ENGINEERING REVIEW will be welcomed at stand bay, No. 6.

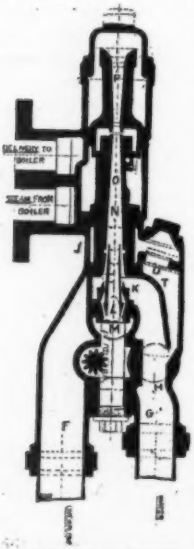
New Motor Mail Service.

THE carrying of HIS Majesty's mails by petrol motor-driven vans is steadily increasing. A new service started last month between London and Aylesbury. The 18 h.p. "Siddeley" van which is being used is supplied by the Wolseley Tool and Motor Car Co., Ltd. It leaves Aylesbury at 7.30 each evening, and calling at Tring, Berkhampstead, Two Waters, Kings Langley, Watford, Stanmore and Edgware to take up, arrives at Mount Pleasant just before midnight. Less than half an hour later it starts back again, and stopping at the same places as on the up journey, reaches Aylesbury again just before five. The distance run is just over forty and a half miles each way. The van carries in addition to the mails a sorter, whose operations are conducted by acetylene gas light, for which an installation has been fitted. The same driver makes both journeys.

A New Hot Water Injector.

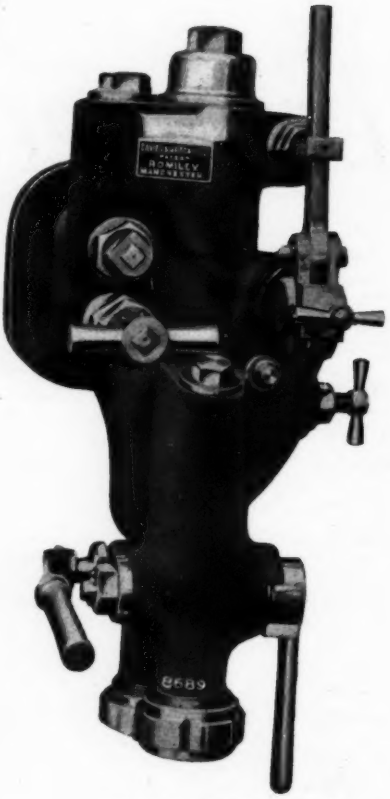
By the courtesy of the makers, Messrs. Davies & Metcalfe, Ltd., of Romiley, Manchester, we are enabled to present some details and illustrations of a new type of combination injector designed for use with hot water. The necessity for such an apparatus has been felt in hot countries and in circumstances necessitating the heating of the feed water before use.

Referring to the sectional drawing: the double steam nozzle, *J K*, comprises a forcing nozzle *J* and a lifting nozzle *K*, steam to which is admitted first through *K* and then *J* by means of the steam spindle *M*, this being accomplished by the gradual withdrawal of the cone-shaped spindle *L*. *N* is the combining nozzle and *O* the flap, the lower portion of the nozzle being in communication with the overflow chamber by means of a gap permitting steam from the lifting nozzle to escape into the passage *F*. The upper portion, which is divided longitudinally and "flapped," provides a large area for the steam from the forcing nozzle to escape and allow the injector to clear itself and restart quickly.



DETAILS OF HOT-WATER INJECTOR.

When, at starting, steam is first admitted to the lifting nozzle, the water is lifted into the combining nozzle, from which it is delivered to the boiler through the discharge nozzle *P* by the action of the steam from the forcing nozzle. In case of interruption of either the steam or the water supply, the injector clears itself through the gap and flap. A specially designed automatic over-flow valve is provided for ensuring a closed overflow, which is rendered necessary by the high temperature of the delivery water, sometimes reaching 250° F. An additional water passage, *T*, is provided which is in communication with the first overflow chamber. Under certain conditions a partial vacuum is formed in this chamber which is utilised to draw in an extra supply of water. Blowing back of the overflow into the supply tank is prevented by the back-pressure value *U*.



NEW HOT WATER INJECTOR.

The claim is made for the apparatus that it may be used advantageously on locomotives in which the feed is heated by steam, to save blowing off at the safety-valves when standing or coasting down banks.

The Special SOUTH AMERICAN NUMBER will be ready on August 10th.

Modern Locomotive Construction.

By J. G. BARWICK SAMS.

In this and succeeding articles the author briefly outlines the methods obtaining in an up-to-date shop devoted to the construction of a modern locomotive. The first article refers to the preparation of the parts, others will deal with the erecting of the prepared parts into a machine ready for the road. (Ed. *E.R.*)

LOCOMOTIVE FRAME

FRAMES have to be made strong enough to counteract the alternate tensional and compressional stresses set up by the steam acting on each end of the cylinders alternately, and also they have the pull of the engine to transmit to the draw-bar. Locomotive frames are arranged vertically between the wheels and are invariably of mild steel plates about 1 in. to 1¼ in. thick. Owing to the gauge, the distance between them is limited to about 4 ft. 2 in.

It will be seen from Fig. 1 that they are merely strong plates shaped out to take the axles of the wheels, and suitably drilled for the attachment of all the engine details. They are rolled from "Siemens-Martin" mild steel ingots containing about 15 per cent. carbon (Fig. 3 *A*).

An average frame-plate ingot weighs about five tons, and will make two plates. After casting and removal of the ingot mould, the ingot is put into a soaking furnace kept up at a constant temperature of about 1,000–1,100° C. which causes the chilled outside of the ingot to be warmed up, and brings the inside of the ingot, which is liquid for a long time after the removal of the mould, down to a proper temperature, thus in a sense annealing it.

After soaking, it is slabbed in a hammer or usually in a hydraulic press, and divided into two. Each slab, after reheating, is rolled out in a mill, first between rough rolls, till it is thinned down, and then between finishing or smooth rolls to the finished thickness. With the last two or three rollings bundles of brushwood are passed through the rolls on the plate; this has the tendency of loosening the scale owing to the crackling of the wood as it is passed through the rolls on the hot plate. Three heats are usually necessary in rolling a large plate.

After annealing and cooling, the plates may be examined for defects; quite a large proportion will be found to be useless for the purpose of main frames owing to flaws, but of course they can be cut up for bogie frames, stays, &c., and other smaller pieces.

The plates are now marked off for punching out from a template which is ¾ in. larger over all edges than the finished size; after which they are straightened where necessary by hammering and passed along to the machining shop. Some firms grind the plates at this juncture on the sides, to take off inequalities.

As it is usual to build ten or twelve engines at a time to a standard design, all the frames will be exactly similar, and so for machining purposes it is only necessary to mark off one in four or one in five. This marking off is done from standard templates, and all edges are slotted in a radius-slotting machine with several heads, and all holes drilled ⅛ in. under standard to allow for final rimering, the frames being piled five or six high, the marked off one being on the top. The frames are now ready for the erecting shop, and here we leave them for the present.

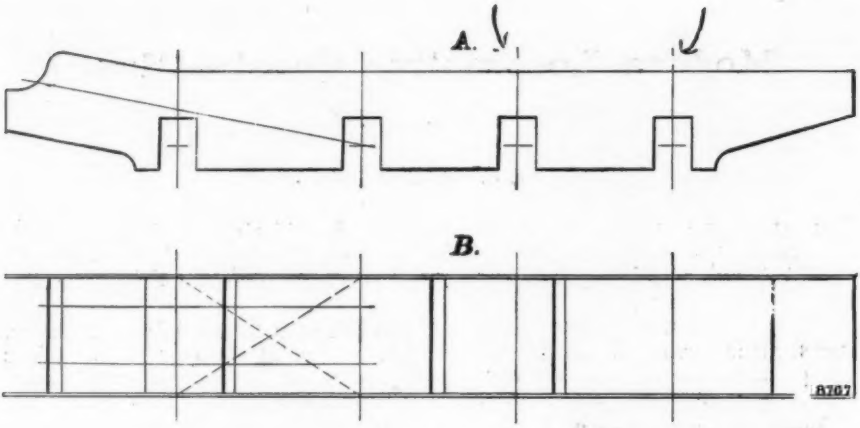


FIG. 1.

WHEELS AND AXLES.

The wheel comprises tyre, wheel-centre, axle, and in a coupled wheel, crank pin.

Tyres are made as follows: The ingots are pear-shape, and vary as the size of tyre; it is usual to cut off the top third of the ingot and scrap it. From this the tyre blank is formed under a hammer or press, and a hole punched through its middle. The blanks are now "becked" in a becking hammer as follows: Each side of the anvil has a massive projecting arm (Fig. 2) on which the tyre blank is hung. The hammer-head is formed so as to roughly hammer the tyre blank into an approximate section, the tyre blank being turned round and round between blows till sufficiently reduced. It will be seen from the diagram that two blanks can be becked at once. After reheating, the blanks are rolled between rollers to the required section and annealed, when they are ready for the machine-shop. By this method it will be seen that there is no welding necessary, and complete homogeneity is ensured.

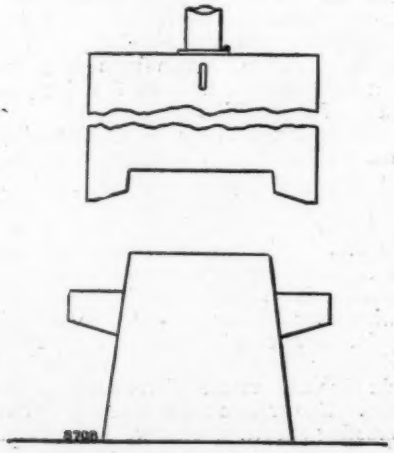


FIG. 2.

The tyres are bored out slightly smaller than their wheel-centres, and are shrunk on to them, a usual shrinkage allowance being $\frac{1}{1000}$ of the diameter of the wheel centre. The tread of the tyre is turned up when the wheel and axle are finished, it being left rough-turned to assist adhesion.

To enable the wheel centre to be placed in the tyre the latter is expanded by heating in a gas furnace, and the wheel centre lowered into it, after which it is allowed to cool; no water should be used for assisting the cooling, as this tends to harden the tyre.

Wheel centres at one time were

forged, but since the introduction of steel castings, are nowadays always cast in steel, forging being a costly job. Some firms, notably the London and North-Western Railway, use cast iron for mineral engines, excepting the driving wheels, which are of steel.

The wheel centres are turned and bored, and in the case of coupled wheels are slotted to match the axle for keys. They are always pressed on to the wheel-seat of the axle by hydraulic pressure, the pressure being about 8 to 12 tons per inch diameter of axle.

A straight axle consists of two journals, two wheel-seats and the shank, while in a crank axle, the two cranks take up the place of the shank. Axles are turned and machined all over and their journals case-hardened, and ground true. A small fractional percentage of chromium is nowadays introduced into axle steel, as this has been found to toughen it.

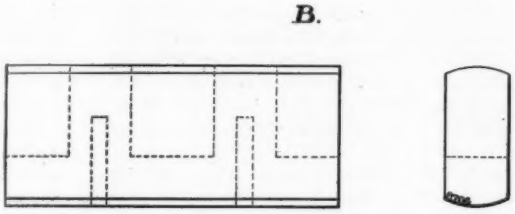


FIG. 3.

Crank axles are either forged, built, or bent, though bending is rather out of date. They are forged from slabs prepared under the hammer or press as explained before (Fig. 3). The bye-metal is cut off, as indicated by the dotted lines, and the cranks roughed up to shape. To bend the cranks at right angles, one crank is held in the press, and the other bent round by a heavy spanner and the use of a crane fall; the bending being done hot. After annealing, it is ready for roughing out in a lathe. The entire axle can be finished up in a lathe, excepting the edges of the crank cheeks, which are usually slotted.

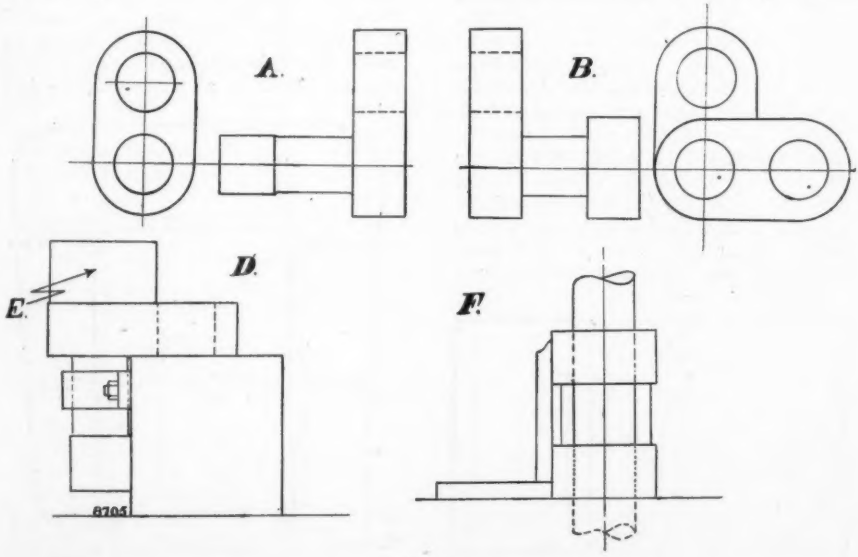


FIG. 4.

The crank pins are turned by fitting an eccentric clamp on to each end of the axle and mounting these in the lathe, so that the centre of the clamp coincides with the centre of the crank pin it is desired to turn. The keyways in driving axles are invariably milled out, while the corresponding ways in the wheel centres are slotted out.

Built up crank axles consist of two pieces of axle for each end, one middle piece of axle, four crank cheeks, and two pins; and they are all machined up, turned, keyways cut, &c., previous to building. It is usual to shrink the parts together, but the crank cheeks are all keyed to their respective pieces of axle in addition.

Fig. 4 illustrates the method of building crank axles. Two cheeks are heated up and shrunk on to the two wheel-end pieces of axle (*A*); also the other two cheeks are shrunk on similarly on to each end of the middle piece of axle; and after cooling, keys are fitted. It will be noted that the cheeks on the middle piece (*B*) are at right angles to each other. After key-fitting, the crank pins are shrunk into the cheeks on the middle piece of axle in the usual way. We have now only three pieces of axle, which are joined as follows: One of the pieces of axle after heating the cheek (*A*) is clamped on a true surface block (*D*) with the axle part vertical, and the cheek flat down on to the block. On top of this cheek is placed a solid distance piece (*E*), and now the middle piece of axle with the crank pins in is lowered down till its lower cheek rests on the distance piece and the crank pin is inserted in the hole in the clamped down cheek (*F*). It is then allowed to cool, when, of course, given the proper shrinkage allowance, the pin will be firmly held.

The other end is done in exactly the same manner. A square placed on the surface block against the edges of the cheeks will enable them to be placed exactly true with each other, hence the three pieces of axle will be in line with each other. After building, it is necessary to take a light skim in the lathe off the axle, so as to ensure its absolute truth. The shrinkage allowance is the same as that allowed for tyres, so it will be seen that very exact turning is required; also the keyways must be exactly marked off, or the cranks will not be at right angles.

Crank pins for wheels are turned all over, and are left with a lip round the inside end for the purpose of riveting over into the countersink left in the wheel-centre.

CYLINDERS &c.

Cylinders are always made from a hard and close-grained cast iron. Inside cylinders are always cast in one, and if it is intended to fit piston valves to them, the cylinders and steam chests can be bored out all at once on a mill;

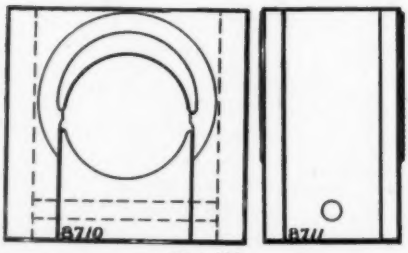


FIG. 5 (*A*.).

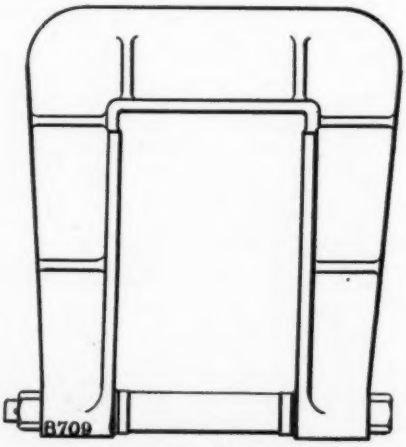


FIG. 5 (*B*).

but for a flat valve, the working face in the chest must be slotted, or shaped.

In boring the cylinders, each end is counterbored a bit larger to prevent a ridge being worked up by the piston at the end of its stroke. For piston valves the steam chests are bushed with steel or cast iron bushes, usually the latter, with the ports cut in them and bridges left in order that the valves will not catch the port edges; these bushes can be renewed when worn. In flat valve steam chests, the port edges are machined to a pattern by a copying milling machine working off a pattern or template.

Pistons are usually of cast steel with cast iron or steel spring rings, which when in position should be $\frac{1}{32}$ in. open. The piston rods of mild steel are turned up and ground true along their shanks, each end having a taper to fit the piston and crosshead with a screwed extension for nuts. Crossheads are steel or iron castings with white metal bearing surfaces; and the guide bars are of mild steel, machined and case-hardened on the faces and ground up true.

OTHER ENGINE DETAILS.

Connecting rods are mild steel forgings, planed, bored and slotted on all working faces, *i.e.*, where brasses or cottars fit, but milled up and polished elsewhere, as flaws show up better on polished surfaces. The small ends are usually brass bushed for the gudgeon pin, and the big ends fitted with some arrangement of adjustable brass.

The London and North-Western Railway tried some cast steel connecting rods, but these soon developed flaws and were condemned, but the C. de F. de Nord is trying castings for coupling and connecting rods at this present time,* but I do not know with what success.

Coupling rods are bushed at each end for the crank pin, and machined out to a channel section, as this style combines lightness with strength. After bushing the coupling rods should be bored out in pairs by a machine with several heads that can be set at the correct standard distance apart. By this method accuracy of pairs of rods for one engine is assured, and the brasses are cheap, and easily renewable.

Eccentric sheaves and straps are usually of cast iron, and the rods of Yorkshire iron. The straps are often fitted with a removable cast iron liner which can be easily renewed. The sheaves are keyed and also held by pinching screws. All the motion pins, &c., are made from mild steel and are case-hardened and ground up true after machining. Axle-boxes, Fig. 5 (*A*), are steel castings with a semi-circular brass strip with white metal insets called a "step" let into the bearing part of the casting for the axle journal to wear against. The edges of the box are planed to wear against the horn block faces. These horn blocks, Fig. 5 (*B*), or axle box guides are of cast steel and are fixed to the frames by rivets. A distance piece and a strong bolt through the ends of the horns are fitted to stay the bottoms of the horns of the frame together.

* *Cf.* ENGINEERING REVIEW, Vol. XVI., pp. 334—336.

Effect of Superheated Steam on Cylinder Oils.

Recently some experiments have been conducted by Messrs. Worrall and Southcombe, of Liverpool University, on the effect of superheated steam on cylinder oils. The oil was injected into a steam pipe leading through a baffle chamber to a condenser, an arrangement which, though not reproducing the conditions found in an engine cylinder, with its fluctuating temperature and relatively cool metal wall, does approximately reproduce those in the steam chest round the admission valves. Fractional distillation of the oil took place; a pitch-like residue was deposited (together with fine iron scale from the boiler) in the baffle chamber, and the distillate passed over to the condenser. From an engineering point of view, however, the experiments are disappointing, inasmuch as they do not tell us anything about the lubricating properties of the oils under the conditions in the engine cylinder.

The Horse Power, Friction Losses and Efficiencies of Gas and Oil Engines.

By L. S. MARKS.

In this paper the author favours the adoption of total h.p. as a unit of power measurement, instead of i.h.p. The latter, he considers, is of no particular use when the b.h.p. is known, and scientifically is less useful than the total h.p.

The presentation of the paper to the June meeting of the Am.S.Mech.E. will doubtless be productive of an interesting and instructive discussion. (Ed. *E.R.*)

For a whole century the i.h.p. of the steam engine has been accepted as the most satisfactory measure of the work done in the cylinder of that engine. When the gas engine came into use it was but natural that the same measure of its power should be used. So long as the whole cycle took place in one cylinder there was but little doubt as to what was meant by the i.h.p. of the engine; but when auxiliary air and gas pumps were used, the i.h.p. required special definition. A committee of the American Society of Mechanical Engineers reported in 1902 a code of rules which contained this special definition, and which has given a consistent meaning to the i.h.p. of steam engines and of gas and oil engines of all types.

The definition referred to is not, however, universally accepted. The pages of the *Zeitschrift des Vereins deutscher Ingenieure*, for 1905, contain a long and most animated discussion by many of the ablest German engineers on the meaning of i.h.p. and mechanical efficiency in two-cycle engines, and they show very marked differences of opinion as to the correct method of calculating those quantities. Within the past few months the definition of the i.h.p. of a four-cycle engine has been the subject of debate by the Institution of Mechanical Engineers, and a strong tendency manifested itself to take as the measure of the indicated work of a four-cycle engine only that area which is included in the positive loop of the indicator card.

I.H.P. AS A UNIT OF POWER CRITICISED.

In all cases it has been assumed that the i.h.p. is the best measure of the work done in the engine, but the differences of opinion as to the methods of its measurement are really indications of the fact that the i.h.p of an engine and the quantities deduced from it, do not give that information which engineers have been trying to extract from them. The fundamental trouble with the i.h.p. as the unit of power is that it does not represent the actual work done by the working substance, but the difference between that quantity and certain resistance. Consequently it does not permit a comparison to be made between the actual amount of work done by the working substances in the cylinders of engines of different types.

I.H.P. AS APPLIED TO A STEAM ENGINE.

So far as the steam engine is concerned, the i.h.p. is certainly the most convenient and probably the most practical method of stating the amount of work that is done in the engine; but for gas and oil engines, it is possible to use another method of stating the power of the engine; a method which is not only more convenient and practical, but

which also gives more information as to the real actions taking place, and forms a better basis for the comparison of the thermodynamic performance of engines of different types.

The i.h.p. of a steam engine is really the algebraic sum of two quantities; these are (*a*) the total work done by the steam inside the cylinder and (*b*) the negative work done in overcoming the frictional and inertia resistance of the steam during the exhaust period. Thus in Fig. 1, if *a b* represents the pressure in the space into which the steam is exhausted, the total work done by the steam in the cylinder is *a c d f b*, and of this the amount *f e a b* is used up in overcoming the resistances to the escape of the steam, leaving the area *e c d f* as the indicated work, or the total work done on the piston.

The work done in the cylinder is not, however, the total work done by the steam, since the steam has to do work in order to overcome the resistance to its admission. In Fig. 1, if *g h* represents the boiler pressure, the area *g h d* is the work that the steam has to do in order to flow from the boiler to the cylinder. The total work done by the steam is consequently the area *g h b a*; and the area *c d f e* (*i.e.* the indicated work) is the difference between the total work done by the steam and the work necessary to get the steam into and out of the cylinder. The total work done by the steam in a steam engine is not shown directly on the indicator card, but has to be obtained by drawing in the boiler pressure line and prolonging the indicator card to meet it.

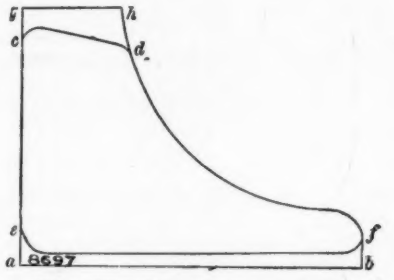


FIG. 1.—INDICATOR CARD OF STEAM ENGINE.

I.H.P. OF AN INTERNAL COMBUSTION ENGINE

The i.h.p. of gas and oil engines is defined by the code of 1902 of the committee on standardizing engine tests, as the power developed in the engine cylinder (the algebraic sum of positive and negative work) minus the power indicated in the separate compression or feed cylinders, if there are any.

In a four-cycle engine, according to this definition, the indicated work is equal to the difference between the areas *a c d e f* and *f a g b*, Fig. 2. If the area *e f b* be added to each of these, the indicated work is seen to be the difference between the areas *c d e b* and *e a g b*. The area *e a b* is the work done in overcoming the resistances to the exhaust of the gas; or in other words the area *e a g b* represents the work that has to be done to get the charge into and out of the cylinder. The indicated work of a four-cycle engine is consequently seen to be the difference between (1) the total work done by the gas, and (2) the work necessary to get the gas into and out of the cylinder.

In a two-cycle engine with separate air and gas pumps, or with preliminary compression of the charge in the crank case, the i.h.p., according to the definition, is the difference between (1) the main cylinder h.p., Fig. 3, and (2) the i.h.p. of the air and gas pumps, Figs. 4 and 5, of the crank case, Fig. 6. In this

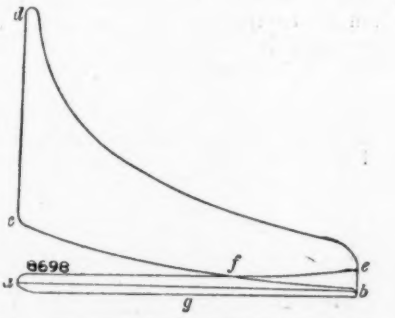


FIG. 2.—INDICATOR CARD OF FOUR-CYCLE GAS ENGINE.

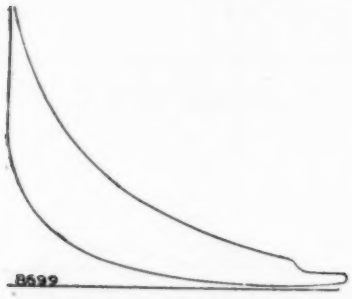


FIG. 3.—INDICATOR CARD OF TWO-CYCLE GAS ENGINE.

engine the exhaust occurs only near the end of the stroke, so that the amount of work done by the main cylinder piston in overcoming the resistance to the escape of the gases is so small as to be practically negligible. The work represented by Figs. 4, 5 and 6 is the work done in overcoming the resistance to the admission of the charge and consequently, in part, the work done in overcoming the resistance to the exhaust, since the incoming charge helps to force out the exhaust gases. The i.h.p. of a two-cycle engine is seen to have practically the same meaning as the i.h.p. of a four-cycle engine.

THE CASE OF THE "DIESEL" ENGINE.

In a "Diesel" motor the conditions are the same as in an ordinary four-cycle engine, with the addition that work is done in compressing the air used to spray the fuel. The i.h.p. from the air compressor must, according to the definition, be subtracted from the i.h.p. of the main cylinder in order to obtain the i.h.p. of the engine. The main difference between the areas *c d e b* and *e a g b*, Fig. 7, is the indicated work of the main cylinder, and, as with the four-cycle engine, Fig. 2, it is the difference between the work done by the gas in the cylinder and the negative work done in overcoming the admission and exhaust resistances. The compressor card, however, Fig. 8, is different from the compressor cards or the two-cycle engine, Figs. 4 and 5. for it represents not only the work required to overcome the frictional resistances of admission of the fuel spray to the cylinder, but also the work of compressing the air used for spraying up to the pressure existing in the cylinder during the admission of the charge. It is obvious that if a large percentage of the air used per cycle in a "Diesel" motor were compressed in the air compressor instead of in the main cylinder, there would be a serious error in regarding the work done in the compressor as part of the frictional resistance to the admission of the fuel. In actual engines, the indicated work of the compressor pump is generally at least 6 per cent. of the indicated work of the main cylinder. It is easily possible by drawing the cylinder admission pressure line *c d* on Fig. 8 to separate the work done there into its two components; the work done in compressing the charge (area *b*) and the work done in overcoming discharge resistances (area *a*). The frictional resistance to the admission of air to the compressor is too small to be shown on the diagram. The total work done by the charge is then the algebraic sum of the positive area *c d e b*, Fig. 7, and the negative area *b*, Fig. 8, the work done in overcoming frictional resistances is the sum of the areas *e a g b*, Fig. 7, and *a*, Fig. 8. The i.h.p. of a "Diesel" motor has the same meaning as the i.h.p. of a four-cycle or a two-cycle engine; it is the difference between (*q*) the total work done by gas, and (2) the frictional resistance to the admission and exhaust of the gases.

FIG. 4.—INDICATOR CARD OF AIR PUMP

THERMODYNAMIC EFFICIENCY CONSIDERED

In the analysis of the performance of a heat engine, there are two principal quantities that the engineer wants to

know, namely, (*a*) the thermodynamic efficiency of the engine, or the percentage of the total heat going to the engine that is actually converted into work, and (*b*) the net efficiency of the engine, or the percentage of the total heat going to the engine that is available for doing useful work. The difference between these two efficiencies is the percentage of the total heat going to the engine that has been used up in overcoming the various resistances which the engine itself offers to the carrying out of the cycle of operations.

It has been the practice in the past to calculate the thermodynamic efficiency by finding the ratio of the indicated work to the total heat supplied. But this does not really measure the percentage of the total heat that has been converted into work; it measures the percentage of the total heat that is available for doing work after certain engine resistances, viz.: those offered to the admission and exhaust of the working substances, have been overcome. The thermodynamic efficiency of an engine should have but one meaning and that is the efficiency of the engine in converting heat into work, irrespective of whether that work is used up, in part, in overcoming engine resistances or remains entirely available for useful applications. That is the plain meaning of the term and the only meaning which will permit a direct comparison of the efficiencies of the processes actually occurring in the cylinders of different engines. If the indicated work is used in calculating the thermodynamic efficiencies, such a comparison does not necessarily throw any light on the actual processes at all, since the frictional resistances resulting from a poor design of compression pumps, valves, ports, &c., may more than offset the gain from the use of a more efficient cycle.

It is, moreover, important that the thermodynamic efficiency should have the suggested meaning in order to permit a fair comparison with the ideal cycle. To state that the thermodynamic efficiency of a gas engine is 60 per cent. of the thermodynamic efficiency of the

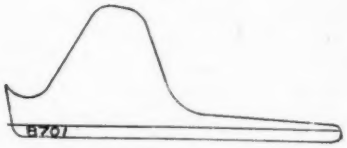


FIG. 5.—INDICATOR CARD OF GAS PUMP.

ideal gas engine working under the same external conditions, is entirely misleading, if the gas friction resistances to admission and exhaust have been subtracted from the total work done by the gas. In some engines, the gas friction resistances may amount to 15 or 20 per cent. of the total work, and if that were the case, an actual ratio of efficiencies of 70 per cent. would appear to be but 60 per cent., that is, the apparent possibility of improvement of the purely thermodynamic processes would be reduced from 40 per cent. to 30 per cent. If the gas friction is taken into account in calculating thermodynamic efficiencies, there does not seem any sufficient reason why the machine friction should not similarly be taken into account. The process of getting the charge into and out of the cylinder is purely mechanical —it is not part of the thermodynamic cycle.

The writer believes that for gas and oil engines, the power of the engine can be most usefully expressed as the total work done by the working substance—this might be called the total h.p., or, since it measures the amount of heat converted into work, the thermodynamic h.p. The total work for a four-cycle engine is the area *c d e b*, Fig. 2; for a two-cycle engine, the area of Fig. 3; and for a "Diesel" engine, the area *c d e b*, Fig. 7, minus the work represented by the area *b*, Fig. 8, of the air compressor card. As measured in this manner, the total work is not entirely independent of the design of exhaust valves and

FIG. 6.—CRANK CASE INDICATOR CARD

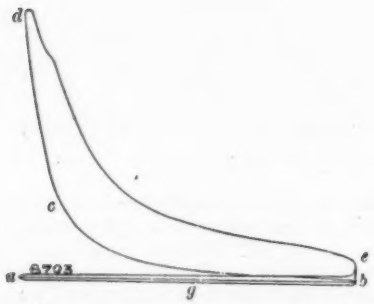


FIG. 7.—INDICATOR CARD OF "DIESEL" ENGINE.

passages since the occurrence of release before the end of the stroke (which is necessitated by the resistances of the exhaust) reduces the total work area. It is only in the case of the comparatively early exhaust of the two-cycle engine that the actual work might be considered as being affected in an appreciable manner by the release before the end of the stroke. It is, however, proper to regard the work of this cycle as being finished when the exhaust opens—the toe of the diagram being the equivalent of the negative area of the four-cycle diagram. Since the area of the toe of the diagram is always extremely small, its inclusion in the total work area introduces no appreciable error.

The total work done by the working substance is used up in three ways:

(*a*) In overcoming the resistances to the admission and exhaust of the charge; this may be called gas friction work.

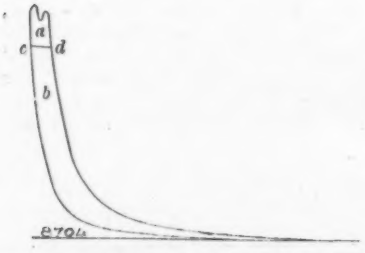


FIG. 8.—INDICATOR CARD OF AIR COMPRESSOR, "DIESEL" ENGINE.

(*b*) In overcoming engine friction; this may be called machine friction work; and

(*c*) In doing useful work.

The i.h.p. is then the total h.p. minus the gas friction h.p., and it retains the meaning it has always had.

An ordinary gas engine test permits the determination of the total h p., the gas friction h.p., the machine friction h.p. and the useful or brake h.p. The value of finding these separate horse powers will be apparent if, for example, a comparison is to be made between two-cycle and four-cycle gas engines. It is urged against the two-cycle engine that it obtains its very great advantage of nearly doubled power per cubic foot of piston displacement, at a cost of considerable loss in efficiency. This loss in efficiency is said to be (1) thermodynamic, resulting from (*a*) the loss of some of the charge to the exhaust during admission, or (*b*) the retaining of too much of the burnt gases in the cylinders; (2) gas friction loss resulting from the separate compression of the gas and air and the consequent extra valve and pipe resistance, and (3) machine friction losses resulting from the actual mechanical arrangements. The statement of the separate horse powers will throw light at once upon all these points, and will show also wherein any particular engine fails to come up to the standard of its class.

COMPARISON OF ENGINE EFFICIENCIES.

From the commercial point of view, there is no advantage in retaining the i.h.p., since it is the brake h.p. that the engine user wants. From the scientific point of view, the i.h.p. can be of use only for the comparative study of engines, and if it is not the best measure of power for that purpose, it should not be permitted to retain its present position.

If the total h.p., gas friction h.p., machine friction h.p., and brake h.p. are used as the standard measures of the engine power and losses, the various

engine efficiencies could be defined in the following manner:

$$\frac{\text{Total h.p.}}{\text{Total heat supply}} = \left\{ \begin{array}{l} \text{thermodynamic} \\ \text{efficiency} \end{array} \right.$$

$$\frac{\text{B.H.P.}}{\text{Total h.p.}} = \text{engine efficiency}$$

$$\frac{\text{B.H.P.}}{\text{Total h.p.—Gas friction h.p.}} = \frac{\text{B.H.P.}}{\text{I.H.P.}} = \text{Mechanical efficiency}$$

$$\frac{\text{B.H.P.}}{\text{Total heat supply}} = \text{net efficiency}$$

Thermodynamic efficiency × engine efficiency = net efficiency.

These definitions retain for i.h.p. and mechanical efficiency their usual meanings.

The thermodynamic efficiency is the actual efficiency of the process of converting heat into work; the engine efficiency is the true measure of all the frictional losses of the actual mechanism, not only the friction of bearings and pistons, but also of the gas entering and leaving the cylinder; and the net efficiency is the quantity that interests the person who pays the bills for fuel. The mechanical efficiency has its use in showing the extent of machine friction losses, but unless the engine efficiency is also stated, it tends to obscure the real magnitude of the more or less avoidable friction losses in an engine.

THE ADVANTAGES OF TOTAL H.P. AS A UNIT OF POWER.

There would be certain incidental advantages from the use of total h.p. as the unit of measurement apart from the more important scientific advantages of a unit which means a single definite thing—and not the sum of two quantities of very different kinds. In ordinary practice, there is more complexity and greater possibility of inaccuracy in the measurement of the i.h.p. of gas and oil engines than in the case with steam engines. The greater complexity arises from the fact that it is necessary in the two-cycle engine to take indicator cards not only from the main cylinder but also from the auxiliary gas and air pumps or from the crank case, and for a "Diesel" engine, it is necessary to take cards from the air compressor as well as the main cylinder. The greater inaccuracy results from the fact that in going round the negative area of the four-cycle, or Diesel-cycle cards, the probable planimeter error has the same absolute magnitude as in going round the positive area, and these two errors may both be of the same sign. If, to avoid this, a weak spring diagram is taken of the work of the exhaust and suction strokes, we have the complexity of another indicator. Of course when scientific results are needed, in which case the gas friction h.p. must be obtained, it will be necessary to take cards from all the auxiliary cylinders, and the greater complexity cannot be avoided; but for ordinary commercial purposes, if any measurement of power is required beside the brake h.p., the total h.p. would serve quite as well as the i.h.p., and it could be obtained more easily and with more accuracy. Commercially, the i.h.p. is of no particular use when the brake h.p. is known, and scientifically it is less useful than the total h.p.

The proposed new measure of power cannot be conveniently applied to the steam engine, nor does it seem desirable to so apply it, since the practice in that case is firmly fixed. In the steam engine, part of the compression work is carried out in the air and feed pumps, but the indicated work in these auxiliaries is not taken into account in calculating the i.h.p.: *i.e.*, a different practice exists from that which the American society recommends as proper for the determination of the i.h.p. for gas and oil engines. The history of the steam engine is probably more in the past than in the future, so that a change in the practice is not particularly desirable even if practicable: but the history of the gas and oil engines is almost entirely in the future, and a proper choice of the units of power may help to make that history more clear.

Machine Tools used in Automobile Construction.

By E. C. AMOS, M.I.Mech.E.

This is the third and concluding article of Mr. Amos' series of articles on the above subject.

HAVING regard to the very rapid growth of the motor car industry, it is not perhaps surprising that disagreement still exists amongst even well-known firms as to what may reasonably be described as vital features. As an instance, reference may be made to the question of power transmission from the engine to the road wheels. One time the suggested use of a live axle for a car over 20 h.p. was considered gross ignorance; to-day we have high power cars, both of the touring and racing type, employing cardan shafts, but there are still many makers, both English and Continental, who stick to the chain system, notwithstanding all its disadvantages. It seems extraordinary that in an exact science such as engineering some agreement cannot be come to on a matter like this.

Then again, there is the question of ignition. One may divide the respective advocates into groups: (1) the high tension battery; (2) the high tension magneto; and (3) the low tension magneto. The conflict is really between the latter two, since the first system, *i.e.* high tension battery, is chiefly used for cheapness.

It will be remembered that to some, similar differences prevailed in the early bicycle days, but to-day, unless the maker's name is seen on the bicycle, it is a difficult matter to tell one make from the other. The average car owner, be he his own driver or not, is not an expert in motor car construction (however much he may fancy himself to be), and what he is asking for is a car which shall carry him safely, without breakdown, and shall be reasonable both in first cost, running cost, and in upkeep.

It is quite true that what the man of £5,000 per annum considers reasonable, the £500 man cannot afford, but in the author's opinion, the time is not far distant when a very great number will own a car who to-day see no prospect of being able to afford it; not necessarily because their incomes will have increased, but because of the reduction in cost of manufacture. Probably the two greatest causes of expense in running a car are depreciation and tyre renewals. The first trouble will grow less when cars are built to be repaired. The second one is likely to be got over by the use of something approximating to a solid tyre.

In view of what has been already said, and assuming that the conclusions arrived at are sound, it will be readily understood why it is that manufacturers have hitherto hesitated to lay down elaborate plants for producing that which in a very short time might be unsaleable. Whilst this state of things is not so acute at the present time, in view of an approximation to a standard type, yet it is undoubtedly the fact that unless manufacturers allow a considerable margin of profit to provide for such contingencies, they find themselves manufacturing at a loss. Again the cost of putting the machine upon the market has been far too high, the difference between maker's cost and the retail price being far greater than the average purchaser has any idea of.

To produce a good car at a low price,

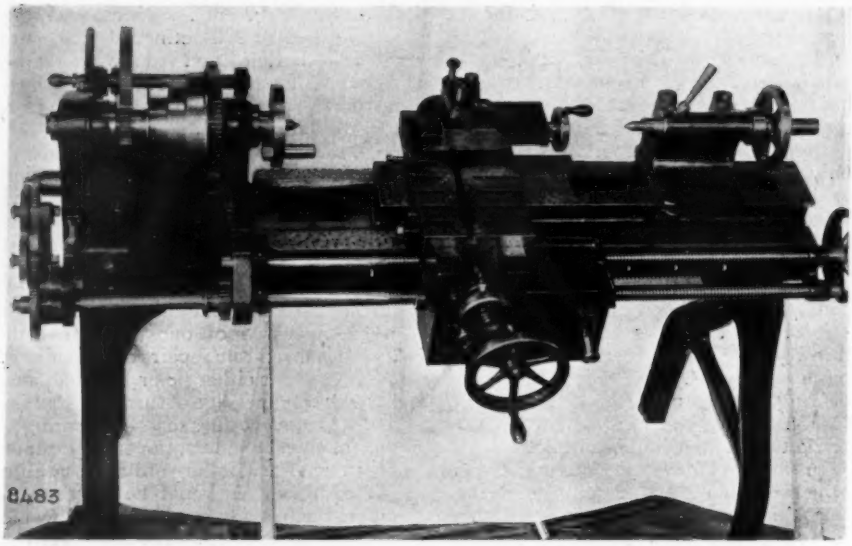
it is necessary to manufacture in large quantities without alteration of design, in the same way as bicycles, small arms, typewriters, sewing machines, &c., are manufactured. The selection of the right material for the duty it has to perform is equally important, and has only recently been recognised in respect to the various grades of steel obtainable. Further, the design should be such that the renewal of parts liable to wear becomes an easy matter. This of course calls for detachable bushes and bearings and other wearing surfaces wherever possible, so that it is not necessary to throw away or renew an expensive piece simply because a pin hole or bearing has worn. Reduced expenditure in putting the finished car on the market is another important factor.

In the early days of motoring it was a very difficult matter outside a big town, and even there not an easy one, to find a shop in which to get repairs carried out. To-day a large number of motor garages and repair shops have sprung up all over the country. This means, of course, that a large number of machine tools are being purchased to equip these works, and there is not the slightest doubt that these plants will increase in number and importance very rapidly. Those firms who are catering for this class of equipment realise that in many cases the proprietor can only afford to purchase, or may be he has only sufficient work for, a few machines, and these must be of such a kind as will permit of their being used for a variety of purposes. This of course differs entirely from the motor manufacturer's method, since he uses a different machine for almost every operation, but then we pay a higher rate in proportion for repairs than we do for the original article, although the motor repairer is gradually getting into line, forced there in fact by competition.

THE DRUMMOND LATHE.

A machine that is finding its way into a good many repair shops is the Drummond lathe. It is made in different sizes, the one shown representing a 5 in. centre self-acting, sliding, surfacing, boring and screwing lathe arranged for power. In cases where no power is available, it is fitted as a foot driven machine.

In designing this tool the makers had in view to provide a lathe which would enable the ordinary garage and repair shop to effect such repairs as are capable of being dealt with at short notice, and its construction meets these requirements. Indeed one might go further and say that the private owner when possessed of one of these little tools need send no repairs out, assuming of course that either he or his chauffeur has some knowledge of turning. Precise and delicate work, such as re-boring a pair of twin cylinders, can easily be done on it, whilst with an ordinary lathe a skilled operator would be required to tackle such a job, and even he would find it very difficult. Having regard to its size, as measured by the height of centres, it is an extremely powerful tool, and will do the work of an ordinary 6 in. or 7 in. lathe. As an example of its capacity, it will take a heavy cut in rough cast iron 14 in. diameter when worked by treadle motion, and will at the same time execute light and delicate work with the greatest accuracy. Certain special features in the construction of this machine may be noted. In order to ensure great rigidity to the saddle, especially when turning large diameters close to the face plate, the slide rails on which the saddle is guided are formed at the level of the bottom of the gap and extend right along the gap space, instead of being formed at the top level and stopping off at the gap space. By this arrangement it is possible to work the saddle over the gap space and close to the largest face plate running in the gap without any overhang either of saddle or tool. Further it becomes obvious that the gap piece can be dispensed with the consequent trouble of removals, cleaning and replacing. The accuracy of a straight bed lathe is retained, whilst the advantages of a gap bed are also secured. The bed is of



MESSRS. DRUMMOND'S 5-IN. LATHE.

true box section with heavy side gibs and the usual cross braces. This is much more rigid than when the usual practice is adopted of slitting the bed right through to form the ways for the tail stock guide. The cross slide of the compound rest is provided with a ⊥ slotted boring and milling table of ample dimensions. This will be found exceedingly useful for ordinary boring, &c., and in addition it permits of boring, at one setting, parallel holes in the same casting, such as twin motor cylinders, &c. A micrometer attached to the cross slide screw enables the distance from centre to centre of such holes to be readily ascertained. This table is provided with self-acting cross and longitudinal feeds, so that the lathe can be used as a milling machine for all purposes where a vertical slide is not necessary. The upper slide can be taken away by the removal of a single nut, leaving the table clear for fastening work to. This design of slide offers several very great advantages, and enables a great variety of work to be dealt with.

AUTOMATIC CYLINDER GRINDING MACHINE.

In certain classes of work it is often desirable to internally grind certain portions without revolving the whole casting; or again it may be necessary to true up or grind pins and the like without revolving the whole piece to which the pin is fixed. For effecting this object the Schmaltz patent automatic vertical cylinder grinding machine with planet action spindle will be found exceedingly useful.

This type of machine is built in four sizes, the types illustrated being size 2, and is specially suited for dealing with ordinary motor car cylinders up to 7 in. diameter by 13 in. deep.

In designing this machine the question of rigidity was given great prominence, as will be seen by reference to the illustrations. The upper part of the main standard carries the planet spindle carriage which moves the long flat slides, and is counter-balanced by weights in the body of the machine. The grinding spindle whilst rotating and

circling can be easily adjusted both for diameter and depth.

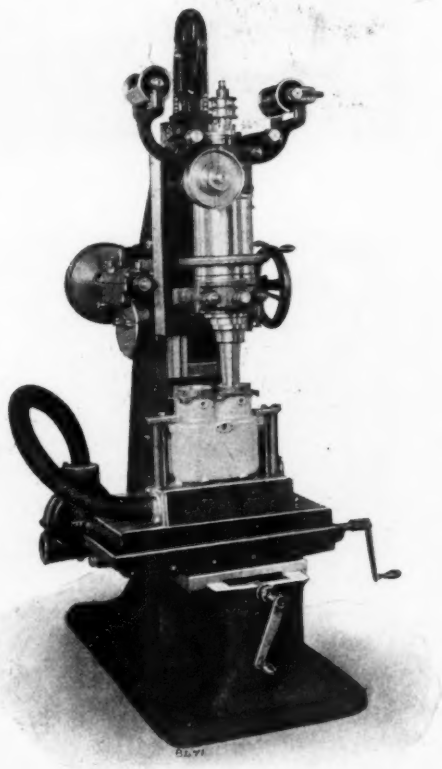
The spindle is driven by a belt running over compensating pulleys, which provide for an equal tension in the belt in all portions of the grinding head. The machine is fitted with compound swivel table measuring 28 in. by 12 in. The spindle is really compound, that is to say, it consists of an inner spindle carrying the grinding wheel running at a high speed, and lies eccentric in a second spindle which again lies eccentric in a third spindle, the outer spindles running together at a slow speed. By altering the relative position of the inner or grinding wheel spindle with its surrounding outer spindles, which can be done whilst the machine is running, the bearings of the inner spindle become more and more eccentric, therefore the grinding spindle, besides its own rotations, describes a circling or planet movement, by means of which hollow cylinders, bolts and pins may be ground. When it is desired to grind plane surfaces the inner spindle is arranged to run concentrically with the outer spindles, and the work is caused to travel. When it is desired to bore cylinders or grind pins the eccentric movement above referred to is effected, and the grinding spindle therefore circles round the work inside or outside, as the case may be.

In the machine illustrated the eccentricity obtainable of the planet spindle is 13-16 in. radius. Amongst the advantages claimed by the use of this machine are greatest possible precision, giving an exactness between ·005 to ·001 millimetres ; (2) rapid chucking of work ; (3) very quiet running and absence of emery dust accumulation, owing to vertical arrangement of the grinding spindle in combination with grinding dust exhaust fan. The machine illustrated weighs about 1½ tons.

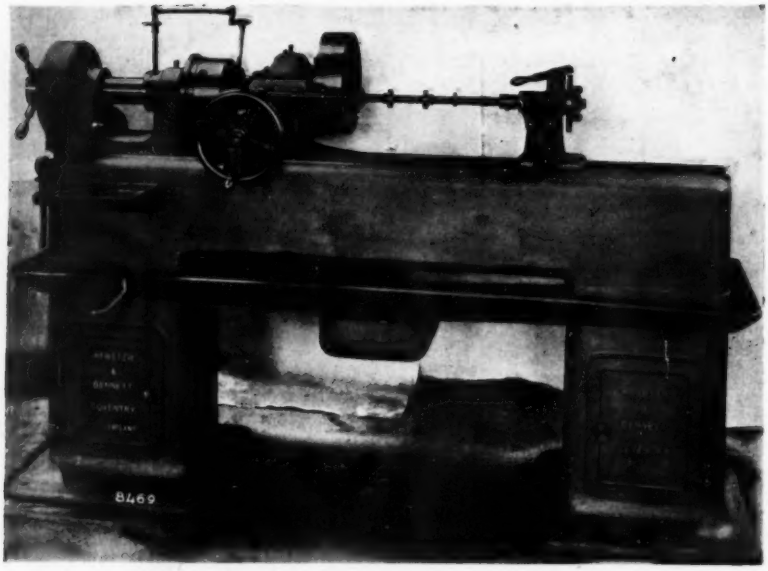
CAM PROFILE MILLING MACHINE.

Promise was made in the last article of a description of a motor cam shaft profile milling machine. This machine, by Messrs. Webster & Bennett, has 6½ in. centres, and has been specially designed for profile milling the cams of motors when they are solid with the shaft. Since its introduction the designer of motor engines has been able to use a cam which is smaller in diameter than would be the case with loose cams, as there is no boss to be allowed for.

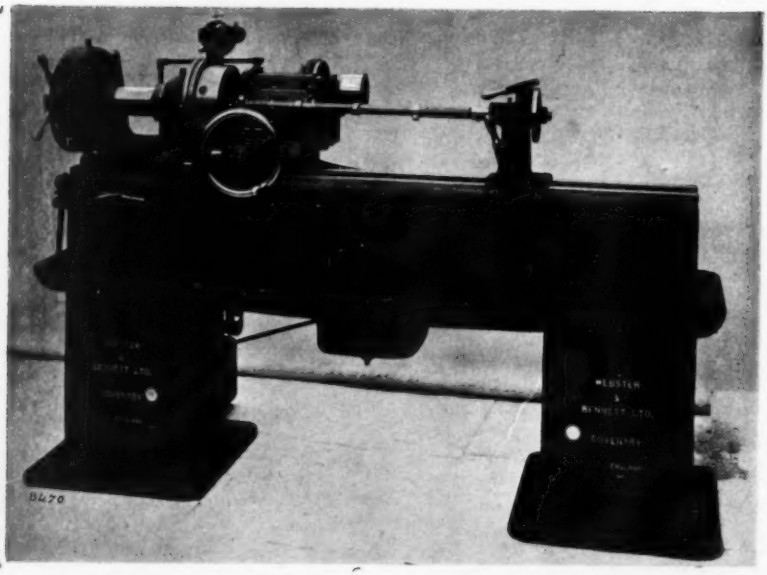
The turned shaft is gripped in the chuck, and each cam milled off the same former, the shaft being passed through the hollow spindle as each cam is finished. The product is highly finished, and what is most important, the cams



THE SCHMALTZ AUTOMATIC VERTICAL CYLINDER GRINDING MACHINE.



MOTOR CAM SHAFT PROFILE MILLING MACHINE.



MOTOR CAM SHAFT PROFILE GRINDING MACHINE.

are in correct relation to each other, and being solid will always remain so. The cutter head slides to and from the bed at the back. The tracer roller is mounted upon it, and is kept up to the former by a weight and chain. A hand wheel at the front withdraws the cutter from the work while changing. The self-centreing chuck grips the cam shaft on its journals or turned parts. The portion operated upon is close to the chuck, behind which is the former plate. This is arranged to give either one or two shapes of cam on the same shaft as occasion demands. The automatic feed motion, which revolves the work against the cutter, is driven from the countershaft by means of worm gearing. The dividing head at extreme right supports the end of the shaft. The use of the division plate ensures the different cams along the shaft being in correct relation to each other. After each cam is milled, the chuck is opened and the shaft moved through the hollow spindle far enough to bring the next cam opposite the cutter. The dividing head slides with the cam shaft, care being taken to withdraw the dividing plunger before starting the feed motion. Loose cams can be milled, if desired, by securing a short mandrel to the former plate in place of the chuck.

When there are three different shapes or profiles of cams for inlet, ignition, and exhaust on one shaft, three copies or formers are of course necessary. These are secured together in the correct relation to each other, so that the angle of the inlet cam to the exhaust cam cannot be affected by the operator, and is bound to remain correct. The division plate is only used in passing from one group of cams to another. Cams that have not much lift can be milled in five minutes. The average cam with 5-16 in. or 3-8 in. lift and about ¾ in. face is milled in ten minutes. The bed is 4 ft. long. The chuck will admit cam shafts up to 2 in. diameter. The driving pulleys are 12 in. diameter and 3 in. wide, and run at 75 revs. per minute. The machine weighs 13 cwts.

CAM PROFILE GRINDING MACHINE.

A somewhat similar type of machine is the Webster & Bennett motor cam profile grinding machine, of which an illustration is given. The cams are of course formed when they enter this machine, and in order to set the cam in correct relation to the copy or former, a template is held on the front of the chuck which clips the first cam, and holds it in the right position while the chuck is tightened on the shaft. This forms a companion machine to the cam-shaft Profile Miller, and when the two are conveniently set a good operator can very well run the two machines.

"Zoelly" Turbine for Manchester.

A contract has been secured by Messrs. James Howden & Co., Glasgow, for a turbo-generator set of engines for the Corporation of Manchester. Seven tenders were considered by the Corporation—four for turbines of the "Parsons" type and three for the "Zoelly" type. The "Zoelly" turbine has made great progress in recent years in France, Germany, Austria, and other Continental countries, and though more expensive to construct than the "Parsons," it is claimed as more economical in working below full power. Messrs. Howden & Co. have made the largest turbine of this type at work in this country —one of 2,000 kw., or 3,000 b.h.p., at the Powell-Duffryn Collieries at Aberaman in South Wales. The company have recently given Messrs. Howden a repeat order for a "Zoelly" turbine, which they have now under construction. The "Howden-Zoelly" turbine which the firm are to construct for Manchester will be of 6,000 kw.—larger than any "Zoelly" turbine now working, and larger, it is believed, than any turbine yet installed in this country for generating electricity, with the exception of one of the same power (6,000 kw.) of the "Parsons" type recently installed by the Manchester Corporation. Messrs. Howden have, it is understood, guaranteed a lower consumption of steam with the "Howden-Zoelly" system, and have undertaken to deliver the new turbine in less time than any other maker. The contract includes the generator, which is a "Siemens" alternator, and the condensing plant, which is on the "Contraflo" patent.

The Franco-British Exhibition.

THE engineering section of the Franco-British Exhibition cannot be said to be commensurate with the importance of the undertaking as a whole, and it is a matter for regret that so few British firms have seen the wisdom of taking advantage of an opportunity for securing publicity, that finds a parallel only in the cases of the exhibitions held at Paris in 1900, Glasgow a year later, and more recently, Dusseldörf and Milan. The British exhibits are in no sense representative of the industry to which a building covering no less than 6½ acres has been devoted, this being more particularly the case in the steam and electrical branches: both are barely saved from oblivion. There is, however, a good collection of machine tools and a sprinkling of gas engines, but locomotive engineering is represented by a solitary, though fine, engine. Shipping and iron and steel have been better supported, the former chiefly by models, of which there is a fine collection.

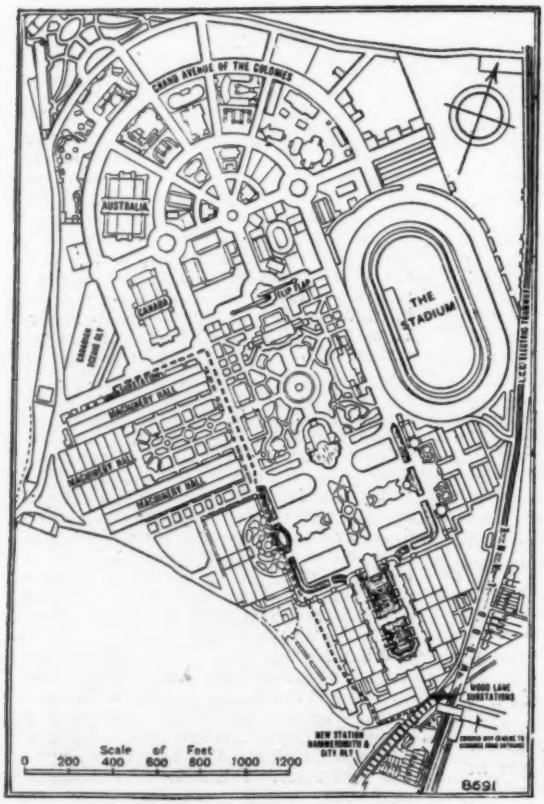


FIG. 1.—GENERAL PLAN OF THE EXHIBITION.

The French side has received even less support than the British and is most disappointing. Further, the state of unreadiness prevailing at the time of writing, does not even permit of commenting, at present, on their quality.

We will commence our review of the engineering exhibits with—

MACHINE TOOLS.

Amongst the machines shown by *Alfred Herbert, Ltd.*, Coventry, are two entirely new tools comprising an automatic turning machine and a ball-bearing sensitive drill, both of which are shown in Figs. 2 and 3. The automatic turning machine, which is fitted with a self-selecting feed motion, is a new line of tool designed for handling in the most economical manner detached pieces, that is to say, articles made from castings, forgings or blanks sawn from the bar. All the operations except the actual chucking

proceed automatically, and when finished the machine stops and the operator removes the finished piece, puts a casting in the chuck and starts the machine up again. In this way it is stated that from four to six machines can be looked after by one man with a corresponding reduction in the labour cost of the work produced. The self-selecting feed motion is a very ingenious device which enables any one of seven feeds to be obtained for any operation by simply placing a small screwed peg in one of the seven holes on each of the feed change dogs. By means of this feature, one set of cams will make any article in the shortest possible time, thereby rendering it unnecessary to touch the cams to change from one piece to another.

The ball-bearing sensitive drill is a two-spindle form of an entirely new range of sensitive drilling machines and is shown for the first time. All the bearings are fitted with balls by which friction is reduced to such an extent that a $\frac{7}{8}$-in. drill may be put through a cast iron plate 1 in. thick in five seconds, which is a very remarkable speed.

Both machines are shown in operation producing actual work. Other more or less familiar examples of the firm's output, also shown in operation, comprise a range of capstan lathes, turret lathe, screw machine, a gear hobbing machine, worm wheel generator, and a selection of self-opening die-heads.

The No. 17 combination twist lathe with the firm's patent chasing saddle is designed for the heaviest type of chuck work up to 20 in. diameter. The machine is equipped with an outfit of tools for producing a cast iron special valve cover plate, which shows in a remarkable degree the advantages possessed by this type of lathe over the ordinary centre lathe, the surfacing and boring lathe, or the vertical boring and turning mill. The speed and accuracy with which threads can be cut by means of the patent chasing saddle will also be noted. The machine has a $5\frac{3}{4}$-in. hole through the spindle, so that when necessary large bars can be conveniently handled.

A No. 5 machine is shown fitted with a single pulley head which may

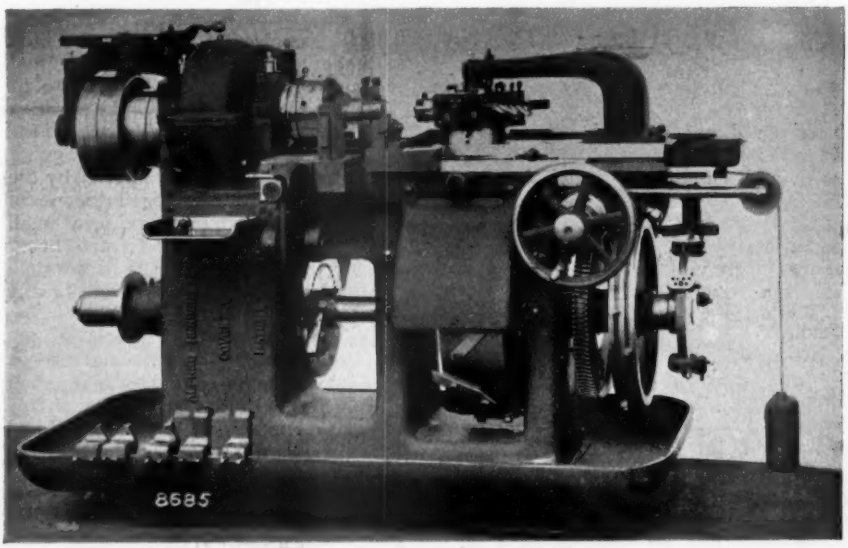


FIG. 2.—AUTOMATIC TURNING MACHINE. ALFRED HERBERT, LTD.

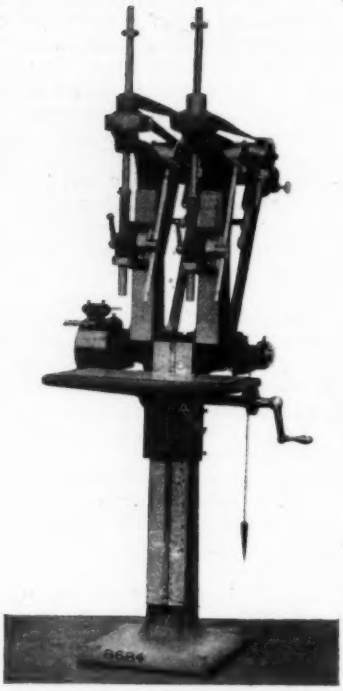


FIG. 3.—BALL-BEARING SENSITIVE DRILL.
ALFRED HERBERT, LTD.

be driven direct from the line shaft and gives sixteen spindle speeds, any one of which may be quickly obtained. The machine is in operation on a casting similar to that being machined on the large lathe, and the adaptability of the tool outfit will be appreciated as it enables a very large range of work to be handled with the one set of tools.

A No. 4 machine is shown in operation on a cast iron commutator bush, and the value of the patent chasing saddle will again be apparent.

A No 2. hexagon turret lathe, 2¼ in. by 30 in., is shown in operation producing work from the bar. This machine is fitted with the firm's "Roller Steady" turning tool, by which a 2-in. bar of 30-ton steel can be reduced to 1 in. diameter at a feed of 6 in. per min., leaving a true, smooth and parallel job. The lathe will be of special interest as it is specially designed for producing direct from the bar, screws, studs, spindles, lock-nuts, pulleys, and other similar articles, which form a large part of the product of nearly all engineering establishments. Owing to the speed with which work can be produced and the ease with which it can be changed over, it pays to make either one or two pieces or a large number at each setting of the tools, and this feature will be recognised as of special value.

A smaller size of the firm's well-known line of automatic screw machines is shown in operation producing a very involved and difficult piece of work from brass bar. The article is a stud or button with a hexagon end, each face of the hexagon being drilled with a fine hole, the centre is bored away, and the front has the firm's name rolled on. The job represents, in miniature, a hexagon turret, and is an example of what may be done on an automatic by an ingenious tool designer.

The gear hobbing machine exhibited is a medium size machine for generating spur gears by the hobbing process, which is now recognised as the correct method of producing accurate gearing, and has the further advantage of a continuous cut. The special features of the machine under review are the quick return to the cutter slide, and the very convenient feed motion. The feed is driven by the work table and is changed to one of three rates by simply moving a small lever, no loose change gears being employed.

Mention must also be made of the worm wheel generating machine. This machine enables worm wheels of any lead to be accurately cut, using either a hob or a single cutter, which, when cutting, is in the same position as the worm that is to gear with the finished wheel. The fly-cutter is fed into the worm wheel blank by being traversed across the blank on its own axis as it revolves. This special design enables worm wheels to be produced with economy, even when only required in

very small numbers. The position of the work enables it to be supported rigidly right up to its diameter, and is equally favourable for work of all sizes.

A special display is made of the "Coventry" self-opening dieheads. The straight cut dies of this attachment have the advantage of enabling different diameters of threads to be cut by the same set of dies using the adjustment to the diehead, and also of being sharpened on a disc grinder or other suitable machine to a constant angle, so that by means of a small grinding attachment dies may be sharpened by unskilled labour with a certainty of all dies in a set cutting alike.

Messrs. John Stirk & Sons, Halifax, exhibit some high-speed electrically-driven tools in operation, including an 8½-in. lathe of improved design for ordinary work. They are shown on stands No. 3 and 110, the latter being occupied in conjunction with Messrs. Sanderson Brothers & Newbould, Ltd., whose "Saben" brand of high-speed tool steel is used on the machines, exemplifying ordinary every-day jobs such as tyre boring and turning, axle turning, &c.

The 48-in. vertical boring and turning mill illustrated in Fig. 4 has some entirely new features. As will be seen, this machine is driven by a direct attached 13 h.p. motor. Two tool posts are provided, each with a swivelling slide and counterbalance arrangement, and independent self-acting positive feeds are fitted for each head, giving nine changes of feed in any direction. The drive is by gear box, giving eighteen changes of speed, and the final motion to the table is by a multiple-thread worm. This forms a special feature and insures a perfectly steady drive, and, as may be seen from the finished work, a total absence of chatter. The table revolves in a bearing of anti-friction metal and the worm and wheel work in a bath of oil. The table speeds are approximately 1 to 50 r.p.m., and the nett weight of the machine, including the motor, is 7½ tons.

The 10-in. centres high-speed self-acting, sliding, surfacing and screw-cutting lathe shown in Fig. 5 is electrically driven by 30 h.p. motor, and is fitted with 16 gear changes giving a range of spindle speeds from 10 to 250 r.p.m. in fine gradation. Two handles operate the changes, and by the gate arrangement used it is impossible to put two into gear at the same time. The headstock and bed are cast in one piece ensuring a maximum rigidity, and the lathe all through is built on the most ample proportions, so that the heaviest possible cuts do not appear to affect the rigidity of the machine. All the gearing is of forged steel and machine cut. The quick-running shafts have ring oiling bearings, and there is an improved friction clutch arrangement allowing the machine to be stopped without stopping the motor. This is useful in measuring work, changing tools, &c. The lathe complete weighs about 7 tons, and is capable of taking

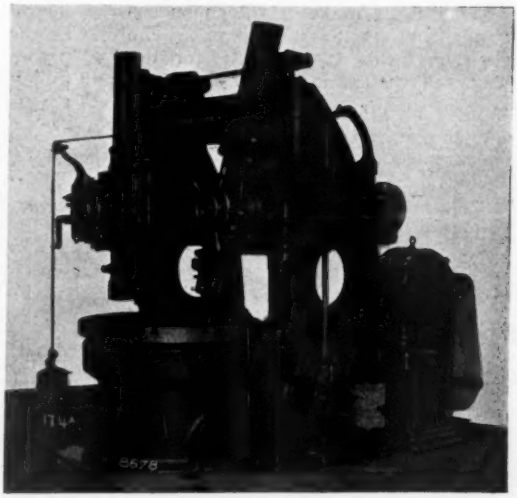


FIG. 4.—48-IN. VERTICAL BORING AND TURNING MILL. JOHN STIRK & SONS.

a cut in ·3 carbon steel $\frac{5}{8}$ in. deep and $\frac{1}{8}$ in. feed at 70 ft. per minute.

The high speed radial drilling machine shown has been specially designed to enable the very best high speed drills that can be obtained to be used to the utmost advantage. It is driven by 13 h.p. direct attached motor. The arm is exceptionally strong, and can be swung on a pillar of large diameter in a complete circle. When in its lowest position it rests on steel balls, but can be raised 12 in. when required. The carriage is firmly gibbed to the arm, and is moved along by rack and pinion. An effective locking device is provided within easy reach. The spindle is ground perfectly true, and is fitted with reversing motion for tapping, and carefully balanced. It has variable power feeds, quick hand movement for withdrawing drill, tapping &c., and a slow hand feed. A special feature is the reversing motion, which consists of a combination friction and positive clutch, and is particularly effective, enabling the spindle to be reversed with great facility. The drive is by gear box, giving nine changes of speed, which can be operated without stopping the machine. A double gear on the carriage makes eighteen speeds in all from 13 to 560 r.p.m. The gear box forms an oil bath for the gears, and the quick-running shafts are made self-oiling, thus securing immunity from trouble through heating of journals. All handles for reversing, feeding, changing speeds, &c. are conveniently placed, and no spanners are required. The machine is guaranteed to drill 1-in. holes in mild steel at the rate of 8 in. per minute, and has, we are informed, been tested beyond this figure.

An $8\frac{1}{2}$-in. ordinary pattern cone-driven lathe, with self-acting, sliding, surfacing and screw-cutting motions, fitted with a quick change feed to back-shaft, completes the exhibit. The machine is a very suitable one for general purposes, and will work at the highest speeds on moderate cuts.

An interesting machine figures on the stand of the *Colchester Lathe Co.*, and is shown in Fig. 6. It is a $9\frac{1}{4}$-in. centre all-gear head lathe provided with a $4\frac{1}{8}$-in. hole through the spindle, thus enabling bars of any length up to 4 in. diameter to be dealt with. The all-geared headstock gives eighteen spindle speeds, which are obtained by three levers conveniently placed for the operator. There are only thirteen gear wheels in the headstock, all of which are steel forgings, only those actually doing work being in mesh. Their arrangement renders it impossible for two gears to be in mesh at the same time, hence avoiding all possibility of accident. The driving pulley runs at a constant speed of 400 r.p.m., thus insuring the full power

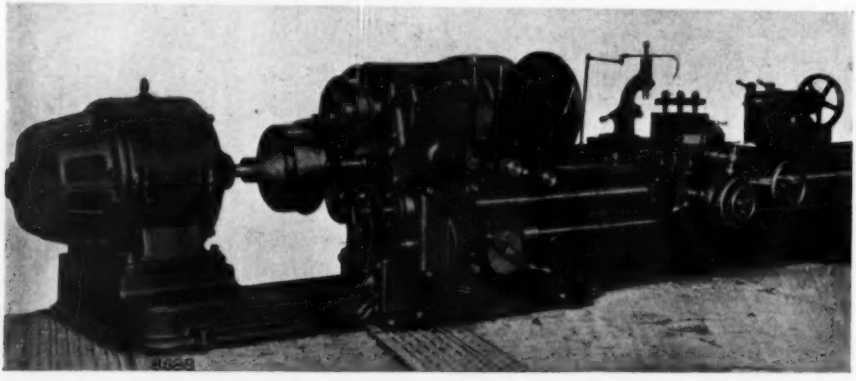


FIG. 5.—10-IN. HIGH-SPEED SLIDING, SURFACING AND SCREW-CUTTING LATHE. J. STIRK & SONS.

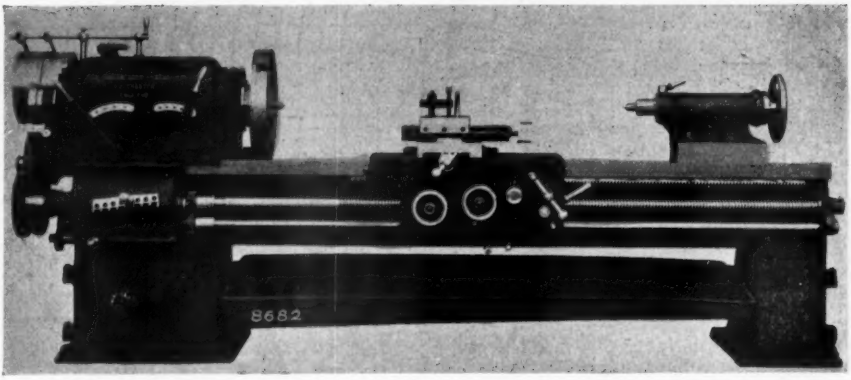


FIG. 6.—9½-IN. ALL-GEAR HEAD LATHE COLCHESTER LATHE COMPANY.

behind every cut. The head is designed to be run direct from the main shaft or coupled direct to a motor. The loose headstock is of very rigid design. The spindle is of large diameter and is truly ground. Two holding-down bolts secure the loose head to the bed. This renders it much easier to move, and eliminates the side strains which are present when the carriage is guided along the bed in the usual way. All gearing in the apron is supported in double bearings, and the sliding and surfacing motions are operated by powerful friction clutches. The gear box is of very strong construction, the wheels being, as already stated, all steel forgings. Thirty-two different pitches of screws can be cut, ranging from two to thirty threads per in., and other threads besides those tabulated can be obtained by extra gears placed on the swing frame. Thirty-two feeds are obtained, ranging from 8 to 120 cuts per inch.

The company also exhibit examples of their high-speed lathes and sensitive drills which have already been dealt with in our columns.*

One of the special features in the machinery hall is the regenerative spring-balanced table planing machine forming part of the exhibit of *Joshua Buckton & Co., Ltd.*, Leeds, an illustration of which is given in Fig. 8. This machine, which is run at intervals during the day, is driven by a self-contained electric motor, and is shown with a recording watt-meter in series which gives an autographic diagram of the power required for driving the machine. A reproduction of one of these power diagrams is given in Fig. 7. The principle underlying the design of the machine is that of balancing the forces by recoil springs. At reversal the springs absorb the energy of the moving parts and return it during the period of acceleration, thus constituting a complete regenerative system. These springs produce beneficial results other than the large saving of power that they effect. Much time is saved by the promptitude with which the machine reverses and attains its full speed. The reversal is extremely accurate; although the machine may be cutting at 60 ft. and returning at 180 ft., not more than $\frac{1}{32}$ in. clearance is required between the tool and any projection above the surface being planed. This accuracy is attained without having regard to modification either of stroke or cut. The two springs abut each against one of the cross bars of the bed or gantry; screws pass through these springs and lie along the whole length of the bed. Heavy bronze nuts are

* Vol. XVII., pp. 334-5.

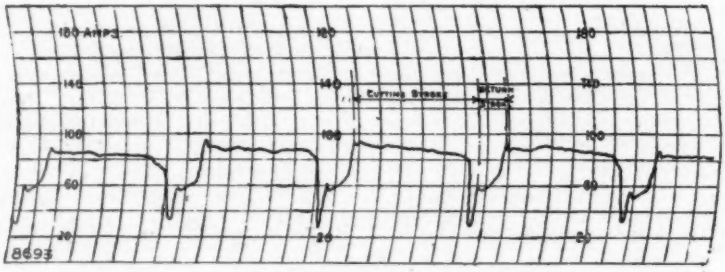


FIG. 7.—DIAGRAM SHOWING POWER REQUIRED ON THE "BUCKTON" PLANER.

adjustable on these screws, and knockers, attached in fixed positions to the underside of the moving table, impinge on these nuts. Any length and position of stroke is obtained by altering the position of the nuts upon the screws by turning the latter. The length of stroke is adjustable down to 12 in.

The stroke may be adjusted while the machine is running. Such adjustments do not disturb the synchronism of the belt striking motion with the spring compression. The return stroke takes place at the constant speed of 180 ft. per minute; the cutting stroke of the machine may be varied through change speed gearing, but although the total range of speed, *i.e.*, from 20 ft. to 180 ft., is in the ratio of 9 to 1, yet no adjustment is necessary throughout this range, and there is no difference in the accuracy of reversal.

The accuracy and rapidity of reversal is not affected by the weight put upon the table. Another feature is that, should the machine be driven by an electric motor whose full load output is absorbed by the maximum cut permissible, then the machine will not impose an overload at the moment of reversal, the net result during maximum cuts being a good load factor.

It may be further mentioned that the machine carries a special power feed and traverse mechanism, arranged to give transverse and vertical feeds to the

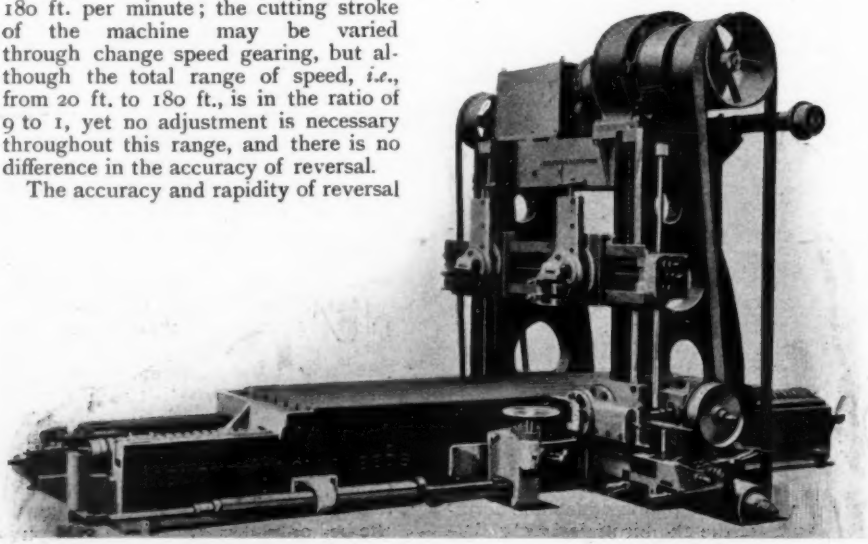


FIG. 8.—REGENERATIVE SPRING-BALANCED TABLE PLANING MACHINE. J. BUCKTON & CO., LTD.

cross slide tool boxes and vertical feeds to the side tool box. This mechanism also gives facility for rapidly traversing any of the boxes in any of their automatic motions, and for raising and lowering the cross slide by power, thus allowing the tool boxes and cross slide to be set for different pieces of work with the greatest ease and rapidity.

On this stand is also shown a patent autographic stress-strain recording apparatus fitted on to one of the firm's 30-ton vertical single-lever testing machines. The system exhibited forms a new departure, inasmuch as the poise weight of the testing machine is stationary and balanced by a spring, which puts the whole steelyard into sensitive, though stable, equilibrium, and no records appear upon the stress-strain curves which can possibly be attributed to the dynamic effects of a moving poise. The whole operation is automatic and entirely independent of the operator, whilst the exact record is obtained right up to the point of fracture, and the yield point and maximum load, the amount of stretched maximum load, and the amount of stretch due to local elongation, are all made visible.

A fine collection of tools figures on the stand of *John Hetherington & Sons, Ltd.*, Manchester, of which we illustrate, in Figs. 9 to 12, those embodying the more recent improvements in construction. The 14-in. sliding, surfacing and screw-cutting lathe is shown in working order driven by a 40 h.p. self-contained, constant-speed "Westinghouse" motor. The saddle is self-acting, sliding and surfacing by back shaft and cut steel pinion and rack along the bed. The fixed ratio of feeds gives 32, 16, 8 and 4 cuts per inch traverse, either sliding or surfacing, and can be readily changed by an indexed lever whilst the lathe is in motion. Quick withdrawing motion is provided for screw-cutting.

The fast headstock has 24 changes of speed, each of which can be made instantaneously, there being no lock bolt or eccentric back shaft arrangement. There are 12 speeds for high speed cutting and 12 for ordinary speed cutting for finishing, screw-cutting and radiusing, &c., all in geometrical progression through treble and quadruple cut gear. The movable headstock is fitted with a sliding spindle of hard steel, adjustable hand-wheel and square thread screw, split nose, locking bolt and centre. It will be seen that all wheels are guarded by neat cast-iron guards.

The machine, as shown, admits an article 8 ft. 9 in. between the centres. The spindle is 7 in. diameter, and the length of front neck 10½ in. The gear ratio for heavy high-speed cutting is 20·36 to 1, and for reducing speed for finishing, radiusing, &c., 162·9 to 1.

The high-speed universal milling machine shown in Fig. 10 is driven by a 12 h.p. "Westinghouse" constant speed motor. The drive is through cut spur gear, self-contained gear box, mitres and spur gears on to the spindle,

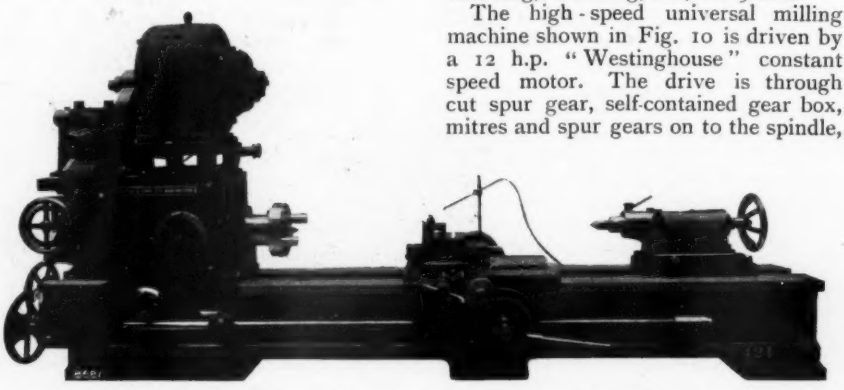


FIG. 9.—14-IN. SLIDING, SURFACING AND SCREW-CUTTING LATHE. JOHN HETHERINGTON & SONS, LTD.

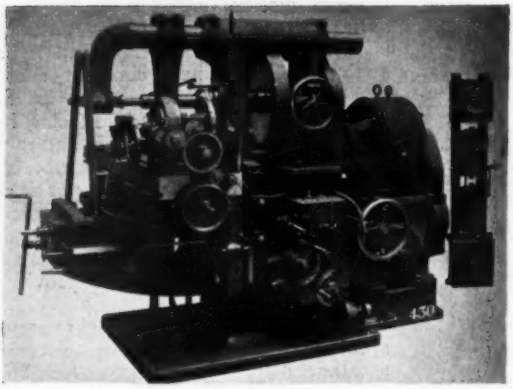


FIG. 10.—HIGH-SPEED UNIVERSAL MILLING MACHINE. JOHN HETHERINGTON & SONS, LTD.

16 spindle speed changes being thus afforded, in geometrical progression, by means of an indexed hand-wheel and levers. The feed motions are reversible, variable, and self-acting, and give a variation of eight speeds to each of the sixteen spindle speeds. Sensitive quick power and hand adjustments to the table slides and knee brackets are provided, all arranged in front, so that the attendant has all the motions under his command without altering his position. The body is of the box pattern and carries the overhanging arm which is coupled to the knee brackets by the removable adjustable stays shown, and is also provided with an intermediate stay for use with the long mandrel. The spindle is $4\frac{3}{4}$ in. diameter at the front end of the cone, the maximum distance from the centre to the full of the table being 1 ft. 9 in. The traverse of the table vertically is 20 in. longitudinally, parallel to the spindle, with the stays off 10 in., and transversely 44 in. The table is arranged to swivel to 90 deg. The width over vees on the knee bracket is 18 in. The dividing heads will admit work 20 ft. 10 in. long between centres, and up to 1 ft. 2 in. diameter. The maximum length of mandrel that can be used with the outer stays on is 2 ft.

Another machine figuring prominently on this stand is a 5-ft. horizontal turning and boring machine, illustrated at Fig. 11, and specially adapted for turning and boring pulleys, fly-wheels, electric generators and general heavy work.

The bed is of strong box pattern with pockets or extension pieces cast on or bolted to both sides and planed to receive the uprights. The top face is machined to give a working face for the underside of table to revolve on. The table is provided with ⊥ slots and a spur ring in one piece bolted on to the lower face, and is lubricated by two rollers working in oil wells. The spindle is of cast iron of large diameter, bolted to the table by turned steel bolts, and revolves in an adjustable double coned cast-iron bearing arranged to take up wear by means of worm, worm wheel, nut and screw, actuated by a shaft which is brought conveniently to the front side of the machine. When high speeds are re-

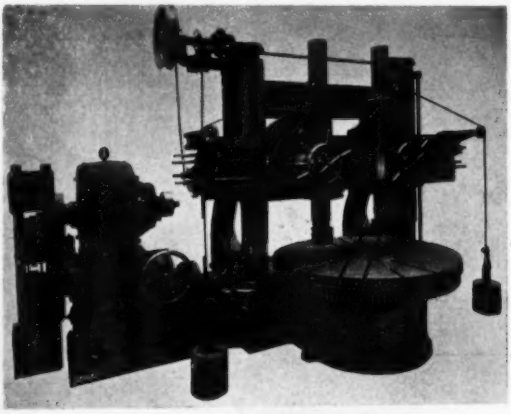


FIG. 11.—5-FT. HORIZONTAL TURNING AND BORING MACHINE. JOHN HETHERINGTON & SONS, LTD.

quired for small diameter work, polishing, &c., the bulk of the table weight may be taken by the spindle. A constant speed 18 h.p. "Westinghouse" motor drives the machine, double, treble and quadruple gearing, giving twenty-four changes of table speed arranged in geometrical progression. The cross slide is elevated and lowered by power by means of pulleys, and is provided with clutch reverse motion. The two tool boxes are fitted with balanced octagonal rams, having an indexed angling or swivelling arrangement by means of a worm and worm wheel quadrant. The lower ends are coned out and fitted with steel tool holders arranged for two tools for boring, turning or surfacing. The feed motions, viz., horizontal, angular or vertical, which are variable, continuous and positive, can be instantaneously changed whilst in motion by means of an indexed hand-wheel giving a variation of eight feeds to each of the twenty-four table speeds. The machine will turn and surface work of diameter up to 5 ft., and will admit in depth under the tool holder up to 2 ft. 6 in.

FIG. 12.—RADIAL ARM DRILLING, TAPPING AND STUDDING MACHINE. JOHN HETHERINGTON & SONS, LTD.

Two high-speed treble-geared, radial arm drilling, tapping and studding machines are also shown, one of which is illustrated in Fig. 12. The box base supports a strong column carrying the radiating arm which works on ball bearings. The spindle slide or carriage is adjustable along the arm by a star wheel, rack and pinion. Single and treble gear is placed on the carriage, thus giving off power direct to the spindle. Clutch reverse motion is provided, and there is instantaneous motion by clutch and lever for reducing the speed for tapping and studding; also quick hand traverse for running the spindle to and from the work. The spindle nose is fitted with Muir's patent coupling and coned bushes for readily securing and releasing the drill. The feed motion is self-acting, continuous and positive through cut gear and cut steel pinion and rack, and can be instantaneously changed whilst in motion by the indexed hand-lever, which gives a variation of three feeds to each of the eight speeds, with instantaneous disengaging motion and hand feed. The leading dimensions are:—Diameter of steel spindle, $2\frac{1}{2}$ in.; cones are suitable for twist drills ranging in diameter from $\frac{3}{16}$ in. to 2 in.; to bore in diameter up to 10 in.; to bore in depth up to 18 in.; maximum and minimum revolution of spindle per minute, 510 and 26; feeds per revolution of spindle, $\frac{1}{128}$ in., $\frac{1}{64}$ in., $\frac{1}{32}$ in.; length of arm from centre of column to outer end,

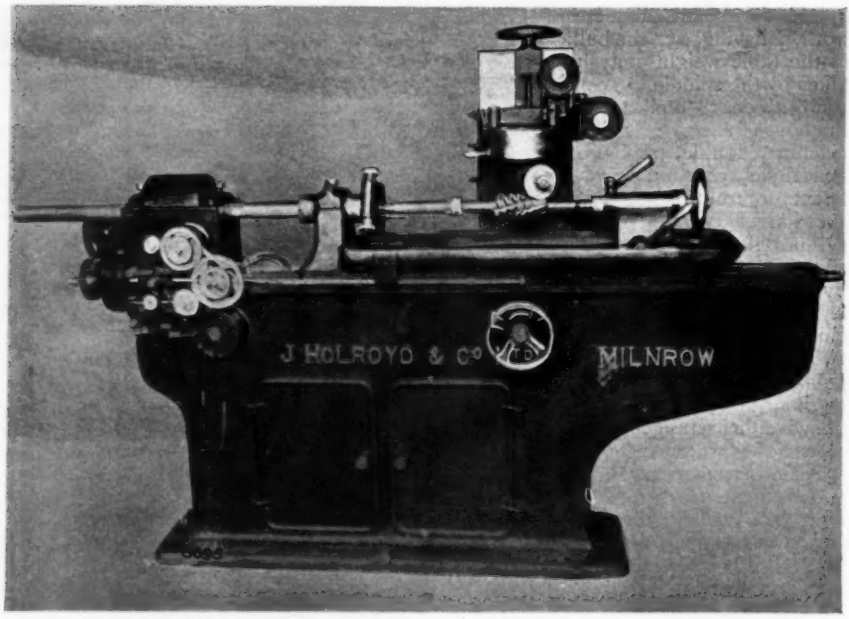


FIG. 13.—HOB-GRINDING MACHINE. MESSRS. J. HOLROYD & CO., LTD.

6 ft. 1 in.; radius of spindle, 1 ft. 3 in. to 4 ft. 6 in.; distance from face of box base to spindle nose, 2 ft. 4 in.

Messrs. Hetherington's fine collection of machines is completed by a 10 in. sliding, surfacing and screw-cutting lathe, a "No. 2" universal milling machine, and a "No. 1" vertical milling and drilling machine with a profile milling attachment.

Messrs. J. Holroyd & Co., Ltd., Milnrow, have a varied display of tools, among which may be specially noted a hob-grinding machine forming the subject of Fig. 13.

This machine is specially designed for the rapid and accurate grinding of hobs. It can also be used for the grinding of spiral reamers, milling cutters, &c. The machine consists of a strong box base, to which is bolted a head with gears for moving, twisting and dividing the hob. On top of this base is a table moving by a screw along slides, and to the top of which is fixed the work heads. An extension at the back of the base provides means of support for slides which carry the emery wheel. The box base is very substantial in design and well ribbed. The slides on which the standard for the emery head works, are broad and strong. The inside may be used as a tool cupboard, and is provided with two large doors for this purpose. The inside of the back extension is closed in at the bottom to form a tank for the lubricant used in the grinding operations.

The head which contains the moving, twisting and dividing gears is very compact. The main spindle which slides right through is 27-in. diameter and slides in a sleeve going through the head. On this sleeve is mounted the differential gear, the centre block of which rotates it. At either side is a worm wheel, one of which rotates gradually for the spiral motion, and the other rotates quickly at the end of stroke to divide. The drive to the head is by a three-speed cone, driving through bevel gearing to the

screw and spindle. The special feature of this drive consists of the fact that the spindle and screw are geared together by change wheels at the end of the head to give the correct pitch of spiral, and inside the gear box at the end of the head are three gears, one on the shaft which rotates the spindle, one on the screw, the centre one on the driving shaft, sliding so that it gears with either of the other two. Thus the drive to the change gears may always be to the end where the smallest wheel is. The change gears for the pitch of spiral are arranged to be the same number of teeth as are used on the universal miller, on which the hobs would be gashed.

The reversing motion is by stop rod and special spring catch operating a clutch which moves between two bevel gears in the drive shaft.

The driving motion is driven by a belt running on a loose pulley and held by a belt fork so that it rubs on a fast pulley sufficiently to drive it the moment the stop catch is removed. The latter is in front of the machine, and is operated by the same lever as the reversing clutch. On the front of the fast headstock is a set of change gears so that one revolution of the stop catch disc divides the hob correctly. The driver plate on the end of the spindle is arranged with a worm and wheel and small star wheel, so that the hob may be automatically revolved for the purpose of putting on the cut.

The operation is thus as follows:—The machine having the hob in, and both sets of change gears correct, is started, the hob moving forward and revolving under the emery wheel, until they run clear of one another, when the machine reverses, and the backlash in gears, &c., carries the emery wheel clear of the hob. At the end of the back movement the operation of reversing also withdraws the dividing stop catch, and the hob moves round to the next tooth or gash. At the end of one revolution of the hob, the star wheel on the driver plate is moved a tooth, revolving the hob forward slightly.

The machine may now be left to continue these operations until the hob is sufficiently ground. The hob table is a strong tee slotted casting with bearing for spindle cast at one end. This is a long parallel bearing, capped, and with brass steps with hardened steel thrust washers. The emery wheel spindle is hardened and ground, and runs in long parallel bearings cast to the head which is arranged to swivel to any angle, graduated in degrees, and is provided with two handles for swivelling and two strong locking handles. The grinding head is carried on heavy slides with vertical and cross adjustment and compensating belt drive, with no weights or swinging jockey pulleys.

Another machine selected from the collection for description is a worm-wheel hobbing machine with a sliding hob, and is shown in Fig. 14. This machine is specially designed for cutting the teeth of worm-wheels by means of a

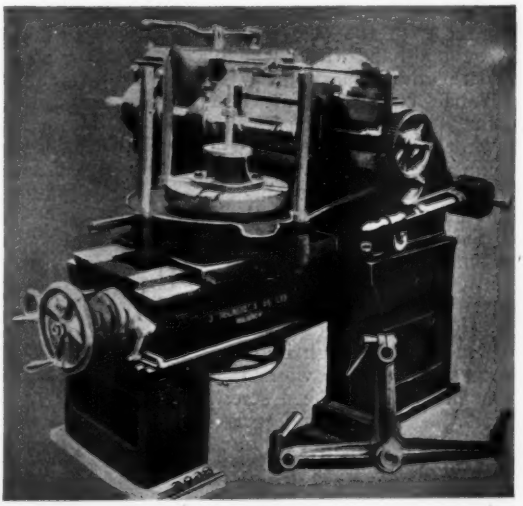


FIG. 14.—WORM-WHEEL HOBBING MACHINE. MESSRS. J. HOLROYD & CO., LTD.

sliding taper hob, or single tool, which travels tangentially across the wheel. It consists of a strong bed mounted on three suitable standards, and carries the work table and cutter headstock. The cutter headstock carries a steel spindle, running in conical gun-metal bearings. The drive to the spindle is by a cone pulley, through spur gears on to the driving sleeve. The cone pulley may drive direct to the spindle, thus giving six changes of speed to the cutter and work mandrel. The spindle is bored out morse taper to receive the hob mandrel, which is held in position by a differential screwed nut. The outer end of the mandrel is supported in a hardened steel bush. The table slide is well gibbed to the bed, and carries a cast-iron sleeve which in turn carries the steel spindle, in which is carried the work mandrel The cast-iron sleeve is screwed on the end to receive the table, and the steel spindle is bored out morse taper to fit the mandrel, which is screwed at the end to fit corresponding hole in spindle. The drive to the work mandrel is by means of change gears, connected to an adjustable worm and worm-wheel.

Vertical adjustment is given to the work spindle, for setting the work central with the cut, by means of a screw and hand-wheel, which is carried underneath the machine.

When cutting worm-wheels with a sliding taper hob, the work must be given the necessary rotative motion to compensate for the sliding of the hob. This motion is obtained from a differential gear box, which is connected to the feed screw of the hob slide by means of change gears, and thus alters the speed of the work to suit the travel of the hob. The feed to the hob slide is derived from the differential gear box, which drives through mitre gears to a drop out worm and worm-wheel which is connected to the feed screw by spur gears. A self-acting knock-off is provided to the hob slide by means of an adjustable collar which releases the drop out worm box.

This machine can be made to cut worm-wheels with parallel hobs. When cutting worm-wheels with parallel hobs, the blank is set central with the hob, and then the hob slide is securely locked in that position. The work is fed automatically into the hob by means of a cam fitted on a disc, which on every revolution actuates a rocking lever connected to a ratchet and pawl mounted on the feed screw. A self-acting knock-off is arranged, fitted with a micrometer disc graduated in $\frac{1}{1000}$ parts of an inch, for setting depth of cut.

Mention may also be made of a fine 4 ft. 6 in. universal gear cutting machine for cutting the teeth of spur and worm wheels. Spur wheels are cut by using a parallel hob or a single circular cutter, worm-wheels by a sliding taper hob, or pointed tool and spirals by a single cutter. On the stand are also examples of screw-milling machines, slot-drilling machine, milling cutter and reamer sharpening machine, and a 5-in. hack sawing machine which has already been described and illustrated in our columns.

The largest stand in this section is that of *Messrs. Sonnenthal & Co.*, of 85, Queen Victoria Street, who exhibit a large variety of tools, many of which have, however, already been described in THE ENGINEERING REVIEW. The collection, which at the time of writing is not yet complete, comprises a number of tools for sawing, cutting off, facing, a wheel lathe, punching and shearing machine, gear hobbing machine, slotters, shapers, and a three-spindle drill.

Messrs. R. B. Rowland & Co., Ltd., Reddish, exhibit a number of tool grinders, including one with a special form of water supply, the water being raised to touch the wheel by lowering displacement floats into a water trough below. The supply can thus be readily adjusted from a trickle to a full volume.

EXHIBITION LIGHTING AND POWER PLANT.

Messrs. C. A. Parsons & Co. have installed in the Machinery Hall itself an 1,800 kw. turbo-generator which will shortly be running continuously for the purpose of generating current for the lighting and power supply of the

exhibition. It is of their standard type, embodying all their latest improvements, and may be taken as an up-to-date example of the "Parsons" steam turbine generator as now manufactured by the firm at their works, Newcastle-upon-Tyne.

The plant, Fig. 15, consists of a steam turbine arranged for driving two dynamos in tandem at a speed of 1,800 r.p.m. The turbine is of their latest improved parallel type, adapted for the full range of expansion from the boiler to the condenser pressure, and is also designed to work non-condensing, and is suitable for working at a steam pressure at the boiler of 150 lbs. above atmosphere and superheated steam; it is also fitted with a governor arranged for a speed regulation within 2½ per cent. permanent and 5 per cent. momentarily when full load is thrown suddenly on or off.

The dynamos are of the latest construction fitted with the firm's compensating windings, which enables sparkless commutation to be obtained at all loads without moving the brushes. Each dynamo is capable of giving an output of 900 kw. at 460-560 volts, and will also maintain an overload of 25 per cent. for two hours, and 50 per cent. momentarily.

The British Westinghouse Electric and Manufacturing Co., Ltd., are, themselves, not exhibiting at the above exhibition, but they are supplying plant and apparatus of various kinds to some of the exhibitors.

To the exhibition authorities a 500 kw. gas-engine generating set has been supplied for lighting the main machinery hall, and for operating machinery therein. This set will operate in parallel with the "Parsons" steam turbine generator set, and consists of a 750 b.h.p. three-crank six-cylinder gas engine of a vertical tandem type recently introduced by the company, direct coupled to a 500 kw. d.c. generator. The gas engine operates on producer gas, supplied from a "Mond" gas producer provided by the Power Gas Corporation. The cooling tower for the water in connection with this plant was supplied by Messrs. Jarvis Bros., Middlesbrough.

For generating electricity for use in their pavilion, the Canadian Government have erected two gas engine generating sets, each of 130 kw. capacity. These engines are of the same type as those supplied for the machinery hall, and each is direct connected to a 130 kw. d.c. generator. The engines are run on ordinary illuminating gas. The Canadian Government have also installed in their pavilion some 48 d.c. and a.c "Westinghouse" standard pattern flame arc lamps.

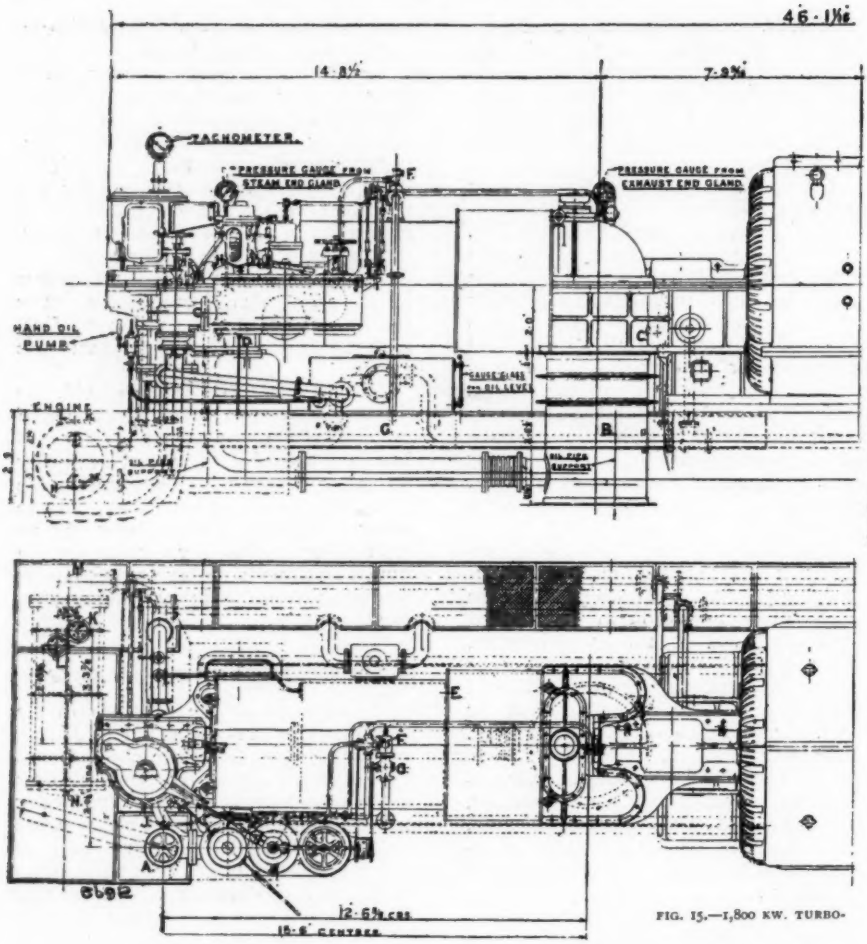
The Australian pavilion will be lighted, and the machinery therein operated, from two gas engine generating sets, one of 100 kw. and the other of 130 kw. capacity. The former engine is a single-crank, two-cylinder, and the latter a three-crank six-cylinder engine, both being of the new vertical tandem type, and both being adjusted for operating on ordinary illuminating gas.

STEAM, GAS, AND OIL ENGINES.

Conspicuous at the entrance to the Machinery Hall is the stand of *Messrs. Mather & Platt, Ltd.*, Manchester, who exhibit a twin-cylinder two-cycle gas engine, with a three-phase generator mounted on the crankshaft between the two cylinders. The normal speed is 107 revs. per min., giving an output of 800 b.h.p. continuously, with a gas supply of about 140 British thermal units per cubic foot; or, in other words, ¾ lb. of coal per h.p. hour.

The three-phase generator is for an output of 2,200 volts, 170 amperes, at 25 cycles per sec., which, with a power factor of 0·8, is equivalent to 520 kw.

There is also a "Zoelly" patent steam turbine pump, coupled direct to a patent high-lift turbine. The set is designed to run at 3,000 r. p. m., and the turbine will develop 210 b.h.p. when supplied with steam at a pressure of 160 lbs. per sq. in., and condensing.



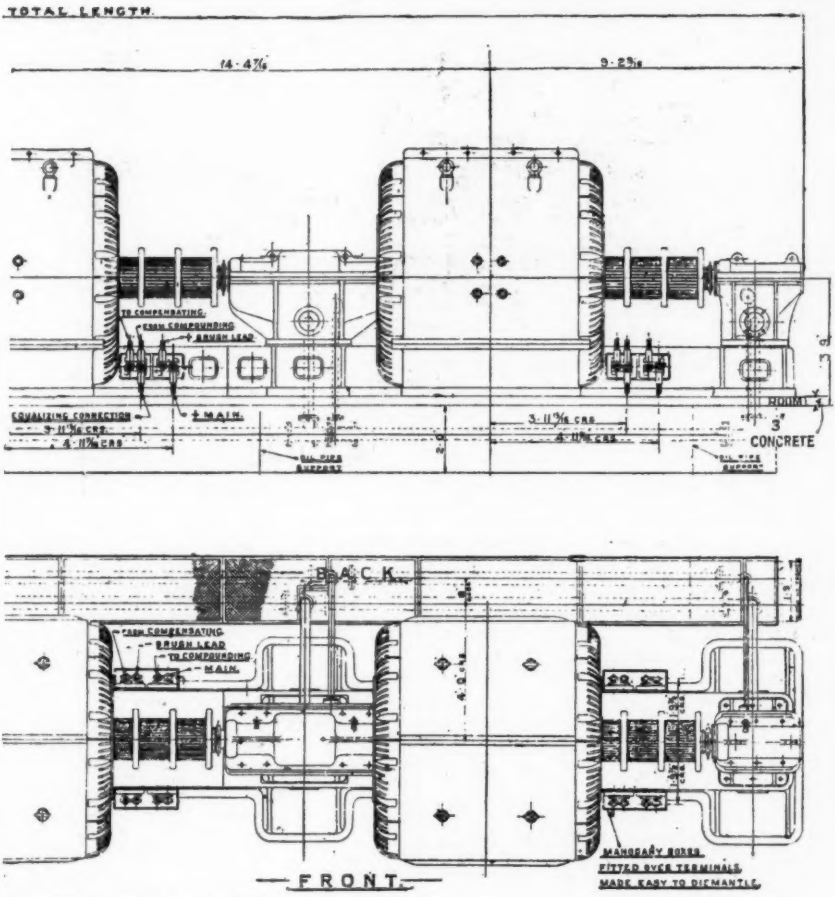
(Continued on opposite page.)

FIG. 15.—1,800 KW. TURBO-

The pump will lift 1,200 galls. per min. against a total head of 400 ft.

Mention may be made also of a pair of patent high-lift turbine pumps direct-coupled to a direct-current steel-clad motor, placed between the two pumps. The motor runs at 1,060 r. p. m., and is capable of giving out 150 b.h.p. The two pumps which have each six successive chambers, through which the water passes, are connected in series, and are capable of pumping 400 galls. per min. against a total head of 720 ft.; that is, each of the twelve chambers in series furnishes pressure sufficient to overcome 60 ft. This is at 1,060 revs. per min.; at 1,450 revs. the output would be 500 galls. per min. against 1,300 ft., and at 1,850 revs. 600 galls. per min. against 2,000 ft. head.

Messrs. Crossley Brothers, Ltd., have a representative exhibit situated at the main entrance of the Machinery Hall. The following comprises a list of



GENERATOR. MESSRS. C. A. PARSONS & CO.

(Continued on opposite page.)

engines:—A 14 by 16 four-cylinder vertical gas engine and dynamo, giving an output of 125 kw.; "O" type horizontal gas engine; horizontal naphtha engine; vertical engine with dynamo of 3½ kw.; vertical marine engine with propeller; a four-cylinder motor car engine, and in addition, a No. 8 suction gas plant.

The suction gas plant is shown as a working exhibit and operates upon anthracite fuel, supplying fuel to the four-cylinder vertical gas engine which is also shown in motion (Fig. 16).

The shaft of this engine is extended and is direct-coupled to a continuous current dynamo built by the General Electric Co. The full working load for the combined plant is 125 kw., the voltage being 220 at a speed of rotation of 250 r.p.m.

Compressed air is used for starting the vertical gas engine. It is obtained from a Crossley "L" type engine and

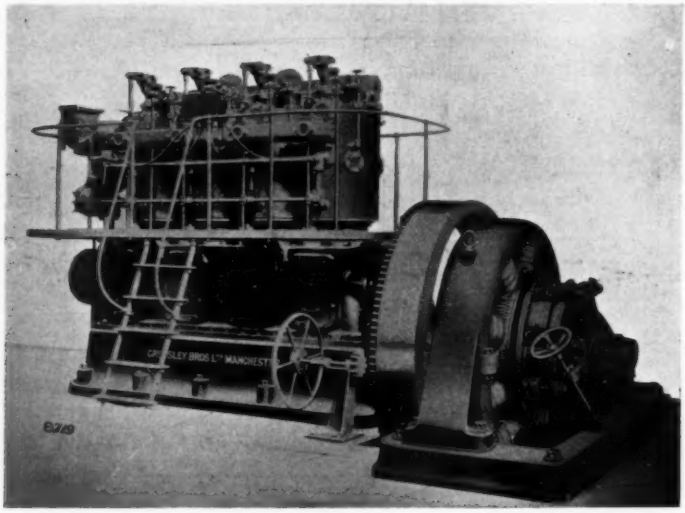


FIG. 16.—4-CYLINDER VERTICAL GAS ENGINE. MESSRS. CROSSLEY BROS., LTD.

compressor which is used to charge three steel receivers to a pressure of 180 lbs. per sq. in. This operation of charging the receivers is only necessary on rare occasions as the loss of compressed air in the tanks is not more than 5 to 10 lbs. upon each time of starting, and a pressure of 80 lbs. per sq. in., within the tanks, suffices to start up the engine. Forced lubrication is fitted throughout the main moving parts of the engine, two valveless oil pumps situated within the engine baseplate being fitted for this purpose. All the oil passes through gauze filters before entering these pumps.

In addition to suction gas, an arrangement is made for working with town gas, and the operation of changing over from one to the other may be performed whilst the engine is running. This important feature is made possible by means of a special type of governing valve with which the engine is fitted.

Another gas engine shown is of the vertical high-speed class. This engine, type "CV1," develops 5½ b.h.p. with town gas when running at 700 r.p.m. It is coupled direct to a dynamo, and the combination is mounted on a substantial cast-iron bed plate. The weight of the complete set is 12½ cwts. This engine is provided with loose, renewable cylinder liners and adjustable bearings. This class of engine is supplied with either one, two, three or four cylinders to work on either town gas, producer gas, petrol, petroleum, benzol or alcohol, and to be used either for stationary, marine, portable or electric lighting purposes. It is intended especially for use when either a limited space is available or where a high speed or a light weight is essential. A two-cylinder marine petrol engine of this class is also shown, type "CV2" coupled to a reversible propeller and intended for use in a launch or similar type of vessel.

Two of the firm's horizontal oil engines are also shown, type "HH" giving 1 b.h.p. at 400 revs. and type "NNN" giving 6½ b.h.p. at 280 revs. The last mentioned engine represents a class which is rapidly gaining favour, owing to its ability to work without alteration with either the ordinary pretroleum lamp oils or with crude oils. No lamp is used except for starting purposes.

The exhibit of *Messrs. W. H. Allen, Son & Co., Ltd.*, Bedford, gives a very admirable idea of the various types of machinery manufactured by the firm at their works in Bedford. Their well-known high-speed enclosed forced lubrication engines are well represented by two examples — one a three-cylinder compound engine, and the other a two-cylinder.

The former is capable of developing 450 b.h.p. when running at a speed of 400 r.p.m., and has one high-pressure cylinder 16 in. diameter, and two low-pressure cylinders 18 in. each in diameter, with a stroke in each case of 10 in.

The main features of the construction of this engine are as follows :—The cylinders are cast in one with the distance piece, and are of a special mixture of hard, close-grained cast-iron. The three cylinders are completely isolated from each other in order that the correct distance between their centres may be preserved at all temperatures, and stand upon a massive and neatly designed trunk, which completely encloses the working parts of the engine, and which also carries the slides for the main cross-heads. The distance piece between the cylinder and the trunk is provided with openings which permit of easy access to the piston and valve rod glands. The apertures through which the piston and valve rods pass into the trunk are fitted with a special form of bush, which effectively prevents oil from passing up into the cylinders, and also prevents water from entering the crankchamber. The whole trunk and cylinders complete stand upon a massive cast-iron bed-plate of box form, which contains a reservoir into which the oil drains, and from which it is supplied at a pressure of about 15 lbs. per sq. in. to all the working parts by means of a small valveless force pump, driven from one of the eccentrics of the engine. The high-pressure piston is of cast-iron, of the solid block type, and is fitted with a solid packing ring of rectangular section. The low-pressure pistons are both of cast-steel and conical in form, and are fitted with "Rowans" packing rings. All three pistons are of equal weight, and the connecting rods and piston rods being all identical, the weights on all three cranks are thus equalised. The cranks are set at equal angles of 120 degs., a very satisfactory balance being thus ensured, the resultant vertical and horizontal forces respectively being practically eliminated, there remaining only two comparatively small unbalanced couples respectively in vertical and horizontal planes. The piston valves are of one solid type without rings, and take steam on the inside edges, thereby reducing the pressure on the glands as compared with valves taking steam on the outer edges, and are driven independently through three eccentrics on the crankshaft. The two low-pressure eccentrics are forged solid with the shaft, and the high-pressure eccentric is of forged steel keyed on. The governor is of the company's standard crankshaft type, the centrifugal force of the weights being carried direct by the main springs

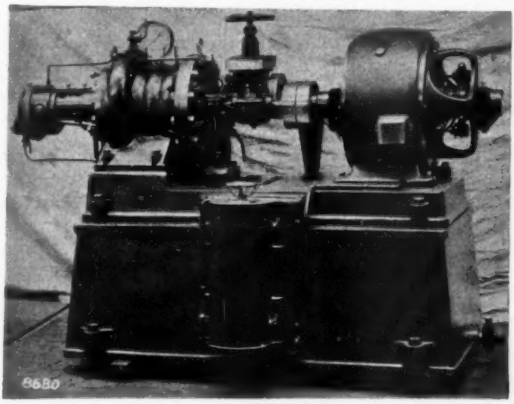


FIG. 17.—FOUR-STAGE ELECTRICALLY-DRIVEN TURBINE PUMP. MESSRS. W. H. ALLEN & CO., LTD.

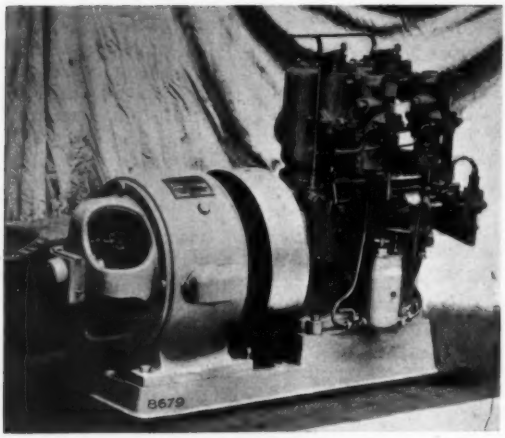


FIG. 18.—TWO-CRANK COMBINED OIL ENGINE AND DYNAMO.
MESSRS. W. H. ALLEN & CO., LTD.

without transmission through any working joints, the apparatus thus being almost entirely free from friction. The governor operates a double-beat throttle valve of special design placed between the stop valve and the engine, the spindle entering the valve box through a special pattern bush, which obviates the use of any packing whatever, and is consequently exceedingly free in its movement. With this type of governor the makers normally obtain governing within a total range of 2 per cent., and hand regulation is usually provided enabling a variation in the steady speed to be obtained of about 5 per cent. above or below the normal.

The two-cylinder compound engine exhibited is of the makers' standard type, capable of developing 220 b.h.p. when running at a speed of 450 revs. per min., and has two cylinders—the high-pressure being 13½ in. diameter, and the low-pressure 19 in. diameter, with a stroke of 8 in. The details of the design of this engine have much in common with those of the engine just described, with the exception of the cylinders, which are cast together with their valve chests in one piece. The two valves are also driven from one eccentric, the valve rods being connected to a substantial steel crossbar within the trunk of the engine, the high-pressure valve receiving steam at the centre and exhausting over the outer edges, and the low-pressure valve receiving steam on the outer edges and exhausting from the centre. The cranks in this case are set opposite to each other, with a view to obtaining a good balance, and the two valve chests are placed on either side of the centre line of the engine, thus enabling the cylinders to be placed as close together as possible, thereby reducing the unbalanced couples to a minimum.

Messrs. Allen's condensing equipment is well represented by two of their standard "Allen-Edwards" three-throw air pumps.

An interesting exhibit on this stand is a four-stage turbine pump, which is direct-coupled to a continuous-current motor (Fig. 17). This pump has branches 4 in. diameter, and is capable of delivering 100 to 120 gallons of water per minute against a head of 200 to 250 ft. when running at 1.700 r.p.m. The pump casing is of cast-iron and the spindle of high-grade nickel steel completely encased with gunmetal sleeves. The four discs are of bronze, and likewise the fixed guide-blades in the casing of the pump. The spindle is carried in bearings of the self-oiling type, arranged external to the pump casing, and at one end is provided with a small collar thrust bearing, which is automatically lubricated and cooled, and which takes up any slight unbalanced end thrust which may occur during running. The glands through which the spindle enters the casing are of special design owing to the high speed of rotation, that at the suction end being water-sealed, the water being drawn from the discharge side of the pump. The drive is transmitted to the pump spindle through a flexible coupling, and great care has been taken in the design of these pumps that the critical speeds of the pump

spindle shall lie sufficiently above the normal speed of working, to give freedom from vibration in running, and the employment of a flexible coupling ensures that these critical speeds will not be modified by the connection with the electric motor.

A three-stage turbine pump is also shown, having a discharge branch 7 in. diameter. This pump is of an exceedingly economical construction, and has internally the same general features of design as those just described in the case of the smaller pump.

Messrs. Allen have recently taken up the manufacture of paraffin oil engines, and these are represented by a small two-crank compound oil engine and dynamo illustrated in Fig. 18. The engine has two cylinders 4 in. diameter by 5¼ in. stroke, and develops 5 b.h.p. when running at a speed of 800 r.p.m., the output of the dynamo being 2·75 kw. at 100 volts. This engine has been designed to withstand rough usage, and is suitable for long continuous runs, with a minimum amount of attention. It is totally enclosed, and splash lubrication is employed, the cam shaft, which is driven by spur wheels, and which also carries the governor, being arranged inside the crank chamber.

BOILER-HOUSE PLANT.

The whole of the boiler-house plant for providing steam for the turbine generating electricity for the use of the exhibition has been supplied by *Messrs. Babcock and Wilcox, Ltd.*

The plant consists of three of their well-known water-tube boilers, each of which has 3,140 sq. ft. heating surface, and is capable of evaporating 10,000 lbs. of water per hour. They are constructed for a working pressure of 160 lbs. per sq. in., and are complete with all the usual mountings and fittings, two of them being set together in one battery, whilst the third stands by itself.

These boilers are essentially composed of three elements, each connected with the other, and in each of which the process of steam raising is separately carried on: (1) a series of inclined water tubes over the furnace, in which the water, being divided into small columns, is quickly raised to a high temperature, and rises through vertical connecting boxes or headers at the front and into (2) horizontal steam and water drums, where the steam separates from the water. The water remaining returns through vertical tubes at the back into the inclined water tubes, where it is subjected to the action of the fire, and again passes into the steam and water drums; (3) a mud collector attached to the lowest point of the inclined water tubes, into which any matter held in suspension is, to a large extent, precipitated, by reason of its greater specific gravity, during the passage of the water, through the vertical tubes and rear headers.

Each boiler is fitted with a superheater having 427 sq. ft. heating surface, and capable of imparting from 100° to 120° F. of superheat to the steam produced.

Each boiler is also fitted with one of the firm's latest design of mechanical chain grate stoker.

The grate consists of an endless chain of short gratebars, which are linked together and pass over drums at the front and rear end of the stoker. The coal is fed over the whole width of the grate, and its depth regulated by a door which can be raised or lowered by gearing. The travel of the grate carries the fuel very slowly towards the back of the stoker; on arriving there the fuel is exhausted, and only ash and clinker remain, which fall over into an ashpit. The power for rotating the grate continuously is transmitted through a gear-box, by means of which four different speeds can be given to the chain. Comprised also in the gear-box is an automatic clutch, which slips if any obstruction prevents the free rotation of the grate. Each stoker is fitted with an arrangement of vanes for cutting off the air supply to a portion of the grate during periods of light load, thus enabling the maximum efficiency to be maintained under such conditions of working.

The power for driving the stoker is

FIG. 19.—THE "NICLAUSSE" BOILER.

supplied by an engine of Messrs. Reader & Co.'s make.

The wrought iron chimney has also been supplied by Messrs. Babcock and Wilcox, but as it was desirable to keep this as low as possible, two induced draught fans, constructed by Messrs. Musgrave & Co., Ltd., Belfast, were installed, one fan being actuated by an electric motor and the other by a direct-coupled steam engine. The water is fed into the boilers by two feed pumps, each of suitable size for feeding two boilers, one pump being left as spare. These are made by Messrs. J. P. Hall & Sons, Ltd., Peterborough.

On its way to the boilers, the feed water passes through one of Messrs. Lessen and Hjort's automatic water softeners, thus eliminating the scale-forming matter from the water before entering the boilers, a pump lifting the water to the softener. The water meter is of Messrs. Kent & Co.'s make.

The whole of the steam, feed and exhaust piping is also of Messrs. Babcock & Wilcox's manufacture, the steam piping being of solid drawn steel, with the flanges riveted on in the case of the larger pipes, and screwed on in the case of the smaller pipes. The steam trap is of Messrs. Geipel and Lange's make. The whole of the lagging is supplied by Messrs. Hobdell, Way & Co., 124 and 125, Minories, E.C.

Another boiler exhibit is that of *Messrs. J. & A. Niclausse*, the well-known French firm, who show one of their standard water-tube boilers fitted with a superheater, with a heating surface of 16 sq. in., and a mechanical stoker. It is capable of generating 2,000 kgs. of steam per hour, the grate area being 2·44 sq. m. and heating surface 81·25 sq. m.

"MOND" GAS INSTALLATION.

A 2,000 h.p. "Mond" gas plant has been installed to supply power for the "Westinghouse" gas engine set in the Machinery Hall, and consists of two of the well-known "Mond" producers of 7 ft. internal diameter, one patent mechanical washer, one gas-cooling tower, two centrifugal cleaners, two scrubbers and a governor. The fuel to be gasified is delivered by means of an elevator into the bunker above each producer, which in turn delivers the fuel into a cast-iron charging hopper at the top of the producer. The fuel on entering the producer from the charging hopper goes into a cylindrical bell, which has for its chief object the maintaining of a constant level of fuel. The gas producer consists of two cylindrical steel shells one within the other, the inner shell being lined with firebrick, the annular space between them forming an air jacket, in which the air and steam blast is superheated on its way to the space beneath the grate, which consists of specially designed fire-bars set radially in the form of an inverted cone. The producer is of the waterluted type with lutes all round, and is so constructed that ashes may be removed at all times without interruption of the producer. In other words, the producer is absolutely continuous in operation. The air blast is supplied by a "Roots" blower.

The gas leaving the producer passes into a rectangular steel washer, in which it is brought into intimate contact with water sprayed up into the form of rain by quickly revolving dashers or paddles. By this means the gas is here freed from dust and partially from tar, and is at the same time considerably cooled down. On leaving the washer the gas enters at the bottom of a gas-cooling tower packed with short earthenware tubes, which effectually distribute over the whole area of the tower the water which is supplied at the top. The gas passes upwards, and on its way comes into intimate contact with the water trickling down. In this tower the gas is much cooled and a large amount of tar is removed. The gas then passes into a pair of specially designed centrifugal cleaners, into which a small amount of water is introduced. Herein the gas is still further cooled down and freed from tar, and when it leaves this apparatus only contains a small trace of tarry matter. This is removed as the gas passes through the scrubbers, which are rectangular steel boxes fitted with a number of trays, on which are placed simple wood planings or shavings and sawdust. The gas then passes in a thoroughly clean state to the gas engine. One of the chief points of advantage in this type of plant is that a very cheap fuel can be used; also, as the gas production is automatically controlled to give only the amount required by the gas engine, even under variable load, all waste of gas is prevented. The stand-by losses are extremely small, and after remaining idle for a fortnight or more, the producer may be brought into proper working condition in about 20 minutes, while after ordinary night stoppages it is only necessary to turn in the blast for about five minutes before the gas is actually required at the gas engines.

CENTRIFUGAL MACHINES.

Messrs. Watson, Laidlaw & Co., Glasgow, are showing a selection of their "Weston" centrifugal machines for separating molasses from sugar, treating chemical crystals, drying laundry and textile goods, separation of oil from metal cuttings, and for the mechanical separation of milk and cream.

A simple illustration of the principle of centrifugal drying is found in the manner in which a sailor dries a mop when wet. He lays it on the taffrail and starts it spinning. The water in the mop and the mop itself acquire a centrifugal force; the water, however, not being fastened to the mop head flies off. The water therefore leaves the textile material of which the mop is made without a squeeze, and the action of getting rid of the water is not interfered with as would be the case in an ordinary wringing machine, nor are the goods damaged by any squeezing effect exerted upon them from without themselves, any such action coming solely from within themselves in virtue of their own centrifugal force.

The foregoing explains the action when drying textile goods or even granular materials, such as sugar, when the revolving basket, having a wire gauze or strainer inside, holds the crystals and allows the syrup to fly out through suitable perforations. The explanation of the action of a cream separator is different; here the milk is rotated in a closed drum or bowl, and, in being so, is subjected to a high centrifugal force, which, acting on the constituents of the milk, has a similar effect to what would happen if the cream became much lighter and therefore suddenly rose to the surface of the milk. The action is continuous and the cream skimmed off as it rises, by suitable mechanical means.

Shown on the stand are centrifugal machines driven by water, electricity, belting and hand-power, while one of the cream separators is driven by a small steam turbine.

To show the different methods of driving in most general use, three 36-in. machines are exhibited, such as are used for separating the molasses from sugar, one being driven by water, one by electricity, and the other by belt. The first is the simplest of all methods of

driving these machines, the motor being a pelton wheel which is attached to the top of the centrifugal spindle, and there is only one bearing in each machine. The water is supplied at the required pressure by a steam pump, the exhaust steam from which is economically used in the various evaporating and concentrative apparatus in the factory or refinery. A simple device is provided for automatically regulating the supply of water to the pelton wheel, so that when full speed is reached, only sufficient water is supplied to maintain the correct speed. The amount of water taken during acceleration may be varied to suit the time in which it is desired to reach full speed.

In the electrically-driven machines the motor is connected to the centrifugal through a slip pulley, which permits of the motor being switched directly on to the mains without the use of any external starting resistance, and the switch is interlocking with the brake, so that the motor cannot be started when the brake is on. One lever controls the starting and braking of each machine. A special device is provided for disconnecting the motor from the centrifugal. to give access to the bearing of the centrifugal without disturbing any electrical connections.

Interest attaches to the spindles of the centrifugal machines. Instead of the load being carried on steel washers as formerly with the "Weston" spindle, and the side pressure taken by brass bushes, both load and side pressure are taken by a ball bearing, and the oscillation of the centrifugal which occurs when the basket is unevenly loaded, is controlled by a self-adjusting conchoidal buffer. This buffer controls the oscillation better than any form hitherto used, and is one of the most important improvements which have been made on the "Weston" machine for many years.

DRIVING CHAINS, &c.

Messrs. Hans Renold, Ltd., Manchester, have a comprehensive display of their driving chains, chain wheels, cutters, &c. The exhibit includes silent chains, bush roller chains, block, stud, balance, textile, pipe wrench, and other special chains, as well as cycle chains. In several cases the parts of the chains are displayed separately, so as to show the construction.

The complete chain drives shown include sizes for powers ranging from 3 h.p. to 40 h.p., and speeds from 400 ft. to 1,300 ft. per minute. In the silent chain drive is included a spring wheel, part of the cover of which is cut away to expose one of the springs. This special form of wheel is used for drives where the load is impulsive, as in pumps, compressors, forging machines.

THE "FLIP-FLAP."

One of the structures erected in the grounds of the exhibition for the amusement of visitors is that known as the "Flip-flap," a view of which is presented in Fig. 20. As it presents various features of interest from an engineering standpoint, we have reproduced the details of the driving mechanism from drawings courteously placed at our disposal by the designer, Mr. Claude W. Hill. M.I.E.E., A.M.Inst.C.E., of Westminster. The late receipt of detail drawings of the structure itself from the constructors, Messrs. The Cleveland Bridge Co., Ltd., Darlington, prevented reproduction, at least, in this number.

As will be seen from Figs. 20 and 21, the "Flip-flap" consists of two arms or masts, each 150 ft. long, turning on a centre pivot and carrying at each extremity a passenger car, capable of accommodating forty-eight passengers in each. The arms turn in opposite directions, one carrying its car from left to right, while the other moves in an opposite direction, from right to left. At each trip the masts turn through rather more than half circle, the speed of the cars being about 200 ft. per min. and the trip occupying $2\frac{1}{2}$ mins.

The arms, which are of steel lattice work, turn on a pivot, supported by steel trestles 20 ft. above the ground level. Each arm is 186 ft. in length, and is pivoted at a point 36 ft. from the end, this inside length forming a tail. In the tail a balance weight is provided

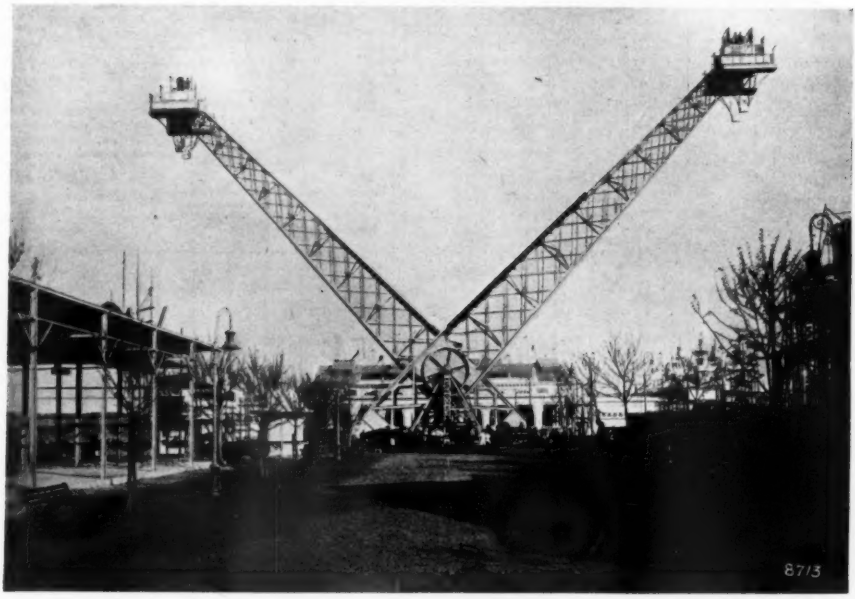


FIG. 20.—GENERAL VIEW OF THE "FLIP-FLAP."

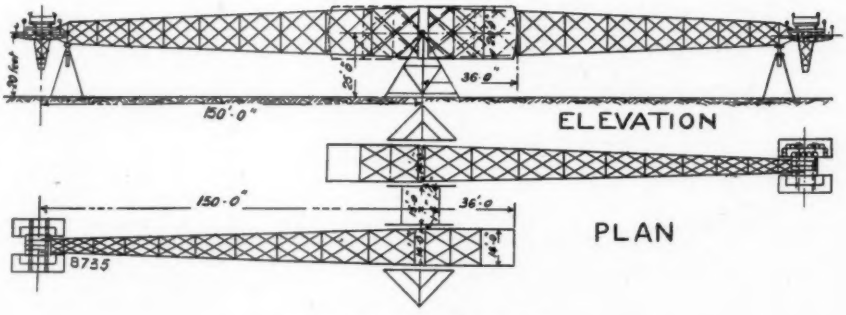


FIG. 21.—DETAILS OF ARMS OR MASTS.

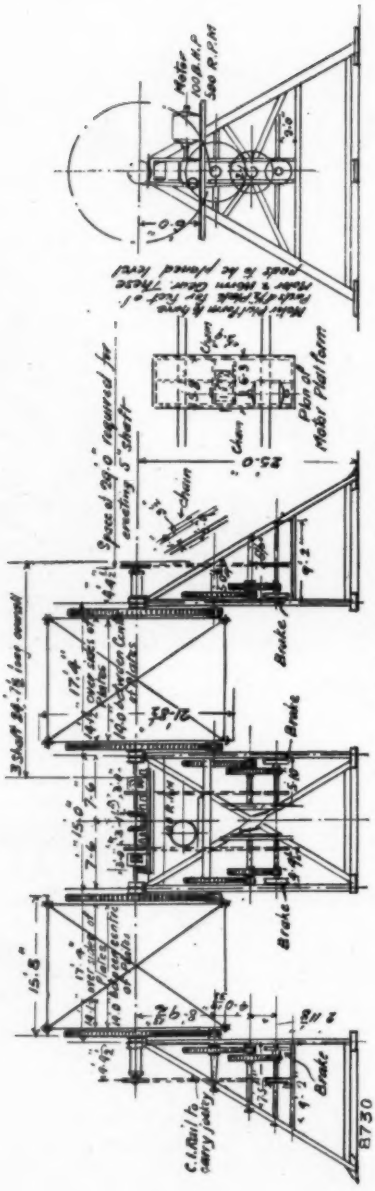


FIG. 22.—GENERAL ARRANGEMENT OF DRIVING GEAR.

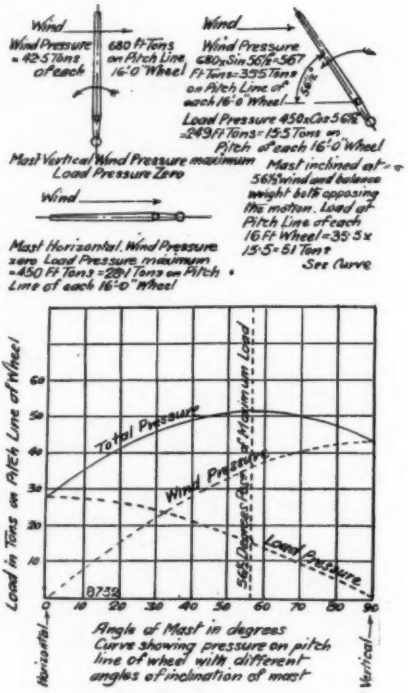

Wind
Wind Pressure = 42·5 Tons of each
680 ft Tons on Pitch Line 16'0" Wheel
Wind
Wind Pressure 680 x Sin 56½ = 567 Ft Tons = 39·5 Tons on Pitch Line of each 16'0" Wheel
56½°
Load Pressure 450 x Cos 56½ = 249 Ft Tons = 15·5 Tons on Pitch of each 16'0" Wheel
Mast Vertical Wind Pressure maximum Load Pressure Zero
Mast inclined at 56½° wind and balance weight both opposing this motion. Load at Pitch Line of each 16 Ft Wheel = 35·5 x 15·5 = 51 Tons See Curve
Wind
Mast Horizontal. Wind Pressure zero Load Pressure maximum = 450 Ft Tons = 28·1 Tons on Pitch Line of each 16'0" Wheel
Load in Tons on Pitch Line of Wheel
Total Pressure
Wind Pressure
Load Pressure
56½ Degrees Angle of Maximum Load
8732
Horizontal
Vertical
Angle of Mast in degrees
Curve showing pressure on pitch line of wheel with different angles of inclination of mast

FIG. 23.—DIAGRAM OF WIND PRESSURES

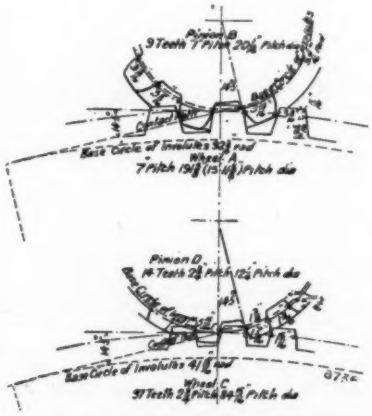

Pinion B
9 Teeth 7 Pitch 20¾ Pitch dia
Base Circle of Involutes 32¾ rad
Wheel A
7 Pitch 131 (13·143) Pitch dia
Pinion D
14 Teeth 2¾ Pitch 12¾ Pitch dia
Base Circle of Involutes 41¾ rad
Wheel C
97 Teeth 2¾ Pitch 89¾ Pitch dia
8732

FIG. 24.—DETAILS OF TEETH PROFILES.

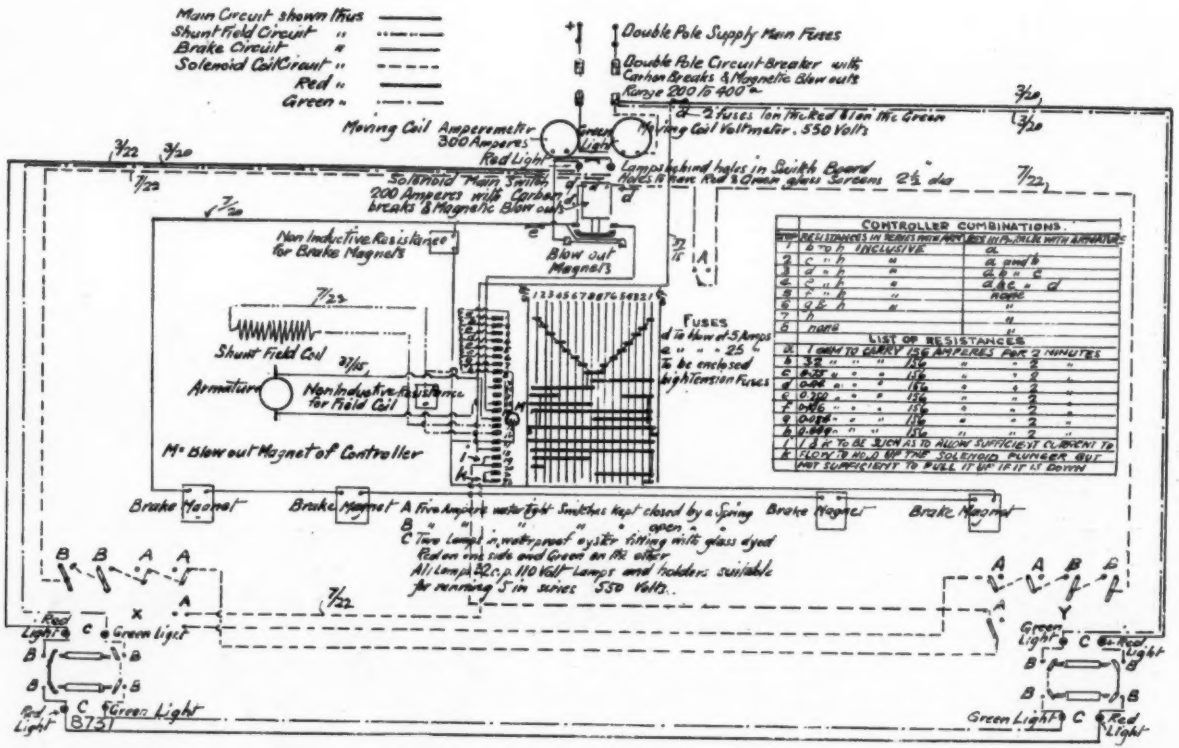

Main Circuit shown thus
Shunt Field Circuit "
Brake Circuit "
Solenoid Coil Circuit "
Red "
Green "
Double Pole Supply Main Fuses
Double Pole Circuit Breaker with Carbon Breaks & Magnetic Blow outs Range 200 to 400 a.
2 Fuses Ton Thicked & Ton Mc Green
Moving Coil Ammeter 300 Amperes
Moving Coil Voltmeter. 550 Volts
Green Light
Red Light
Lamps behind holes in Switch Board Holes 1¼ diam Red & Green glass Screens 2½ diam
Solenoid Main Switch 200 Amperes with Carbon breaks & Magnetic Blow outs
Non Inductive Resistance for Brake Magnets
Blow out Magnets
Shunt Field Coil
Armature
Non Inductive Resistance for Field Coil
Mc Blow out Magnet of Controller
Fuses
d To blow at 5 Amps
e " " " 25
To be enclosed high tension Fuses
Brake Magnet
A Five Ampere water tight Switches kept closed by a Spring open.
B " " " " " "
C Two Lamps in waterproof oyster fitting with glass dyed Red on one side and Green on the other
All Lamps 32 c.p. 110 Volt Lamps and holders suitable for running 5 in series 550 Volts.
CONTROLLER COMBINATIONS.
LIST OF RESISTANCES
8731

FIG. 25.—DIAGRAM OF ELECTRICAL CONNECTIONS.

composed of concrete filled into a large sheet-iron box. This method of balancing not only ensures the expenditure of a minimum of power in turning the arms, but affords a safety device in that, under no circumstances, can the arms suddenly drop. The cars are kept in a vertical position throughout the trip by the provision of counterweights suspended below the centre pin.

The arms are electrically driven by a shunt-wound 100 b.h.p. motor running at a speed of 500 r.p.m., which is placed on the driving platform situated between the two arms. The driver's cabin, containing the main switchboard, controller, and signal lights, is placed at the centre, between the two arms and above the pivot on which they turn. Power is first transmitted through worm and worm gearing (Fig. 30) from the motor, to the central bevel wheels, see Figs. 22 and 28, by means of a vertical shaft, the function of the bevel wheels being to balance the wind pressure on the arms or masts. If this is equal, no load, due to wind pressure, comes on the motor, while if the wind pressures are unequal, the difference only is taken by the motor. From the central bevels the power is transmitted through a differential gear, the details of which are given in Fig. 28, to four driving chains which drive the sets of gearing on each side of each tower. The differential gear equalises the wind pressure stresses on the gearing on each side of the mast, so avoiding twisting stresses on the mast. This gear also serves to equally distribute the driving power of the motor, though that is not their primary object. The latter is to allow for the slight irregularities in the cast teeth of the larger wheels and for the slight differences in length which are certain to occur in the driving chains.

The teeth on the bevels of the differential gear are cut from the solid to Brown and Sharp's proportions with involute faces, having an angle of incidence of 14·5 deg.

On the platforms at the ends locking bolts are provided to hold the ends of the arms firmly when passengers are entering or leaving, and there are red and green signal lights similar to those in the driver's cabin (see Figs. 25 and 27). At the ends there are also emergency switches by means of which the masts

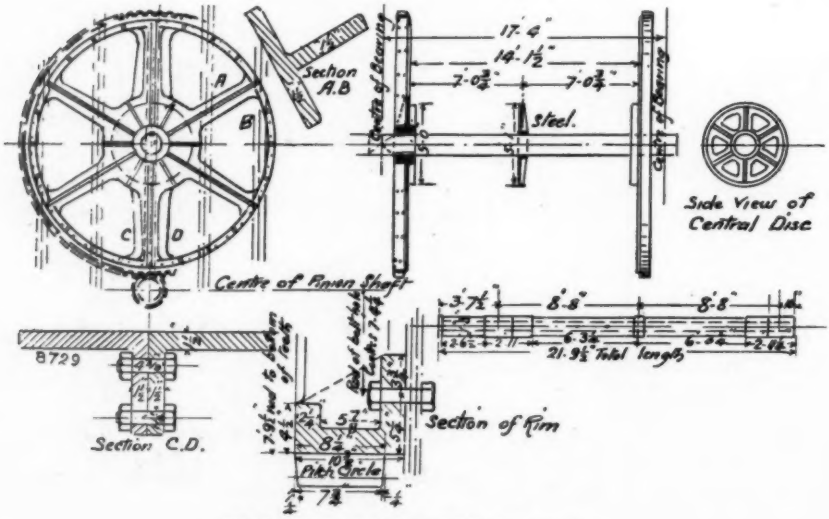


FIG. 26.— DETAILS OF MAIN WHEELS AND SHAFTS.

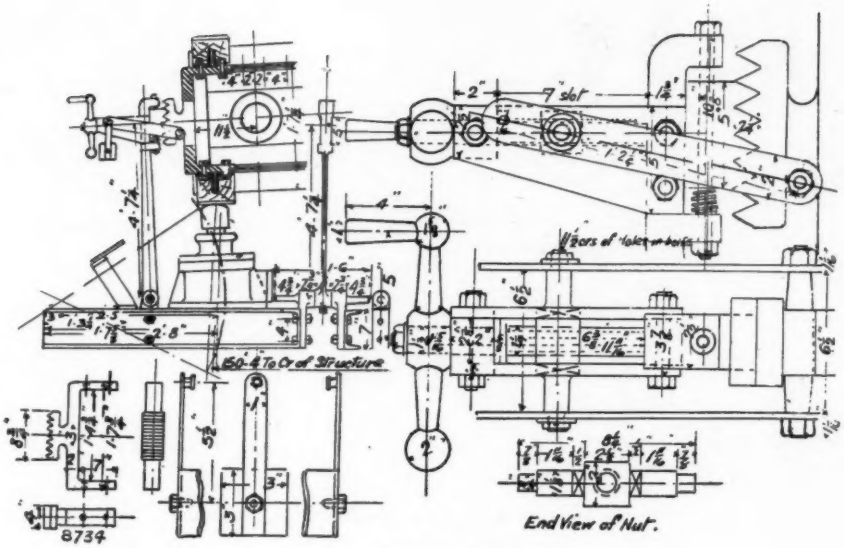


FIG. 27.—DETAILS OF LOCKING GEAR.

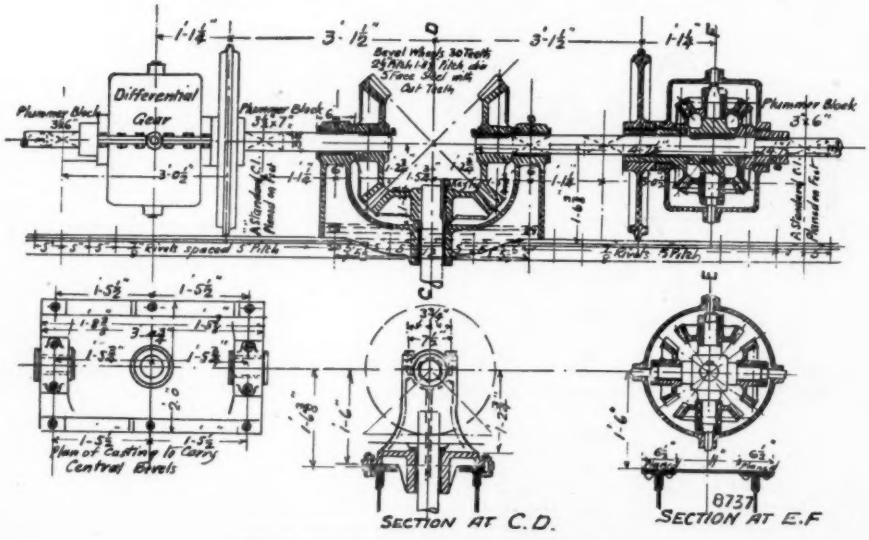


FIG. 28.—BALANCE BEVELS AND DIFFERENTIAL GEAR.

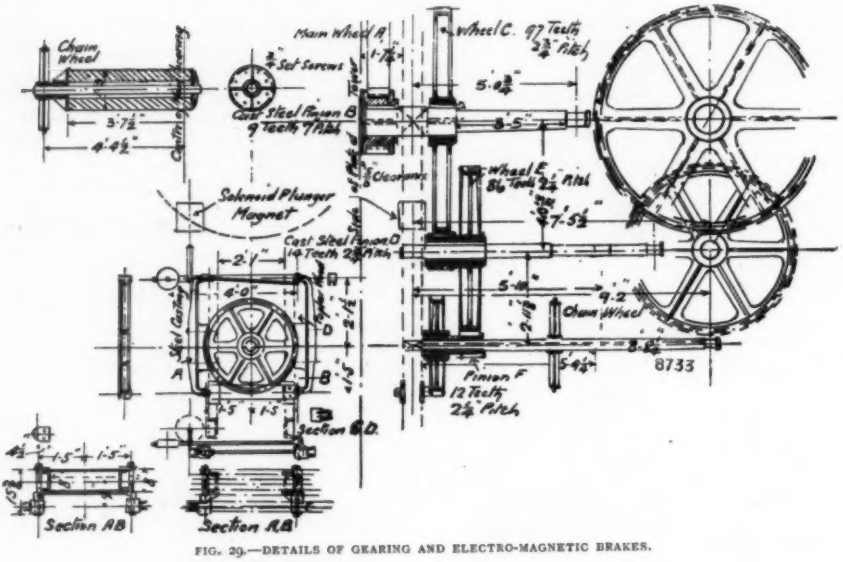


FIG. 29.—DETAILS OF GEARING AND ELECTRO-MAGNETIC BRAKES.

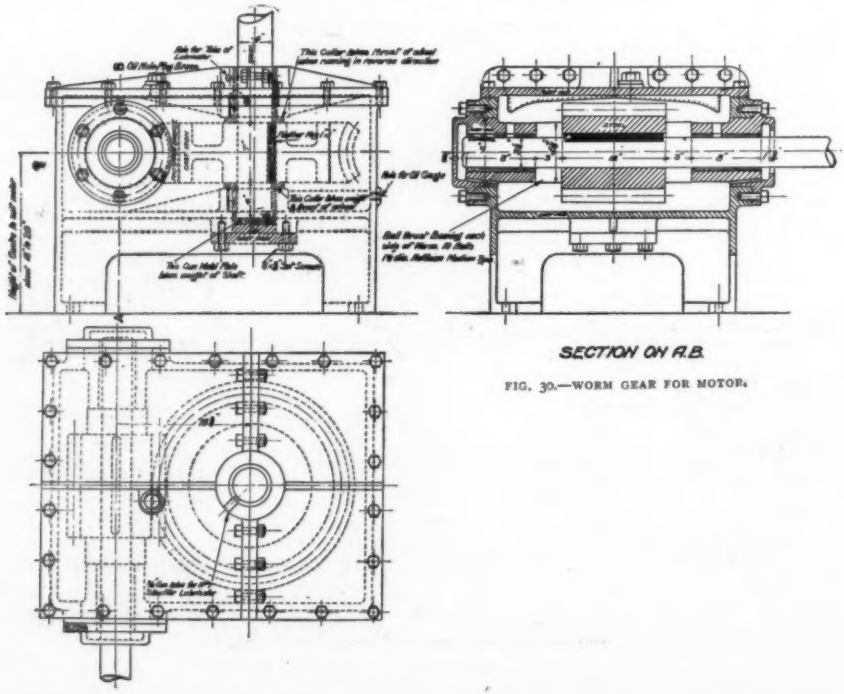


FIG. 30.—WORM GEAR FOR MOTOR.

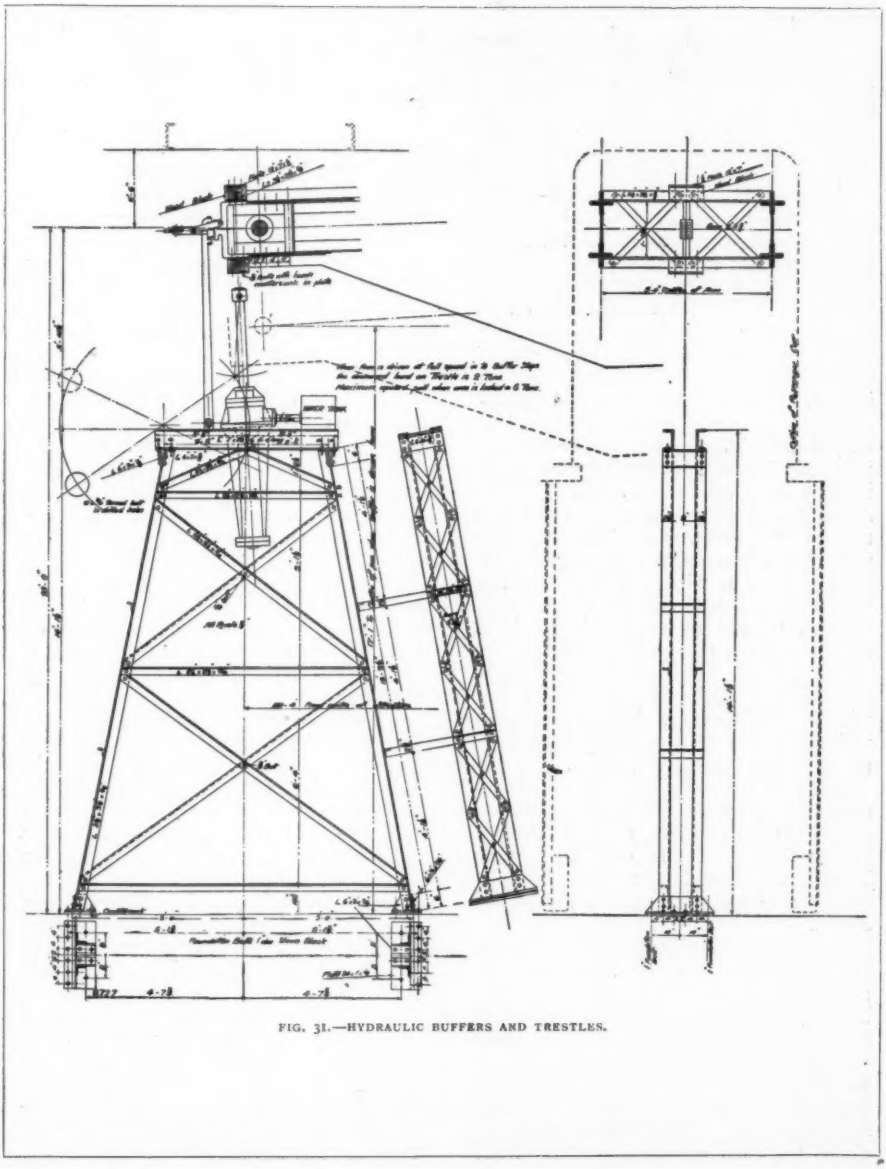


FIG. 31.—HYDRAULIC BUFFERS AND TRESTLES.

can be stopped at any time, in case of accident, without waiting to communicate with the driver. Limit switches are also provided which will cut off the current and set the brakes if the driver overruns the correct place, and hydraulic buffer stops (Fig. 31) are fitted to bring the arms, in any case, gently to rest.

The maximum pull on each of the four driving chains is 1,520 lbs. The main wheels which carry the arms are 16 ft. diameter and are of steel, cast in halves. Each wheel is bolted to the mast with 86 bolts, $1\frac{1}{4}$ in. diameter, and 60 bolts 1 in. diameter, making in all 584 bolts, 5 in. in length. The teeth of these wheels, of which details are shown in Fig. 26, are machine moulded to profiles shown in Fig. 24. The details shown in Fig. 29 refer to the electromagnetic brake gear: each brake wheel is of cast iron, 34 in. diameter by $4\frac{1}{2}$ in. wide between flanges. The shoes are of poplar wood. The solenoid plunger magnets of these brakes give a pull of 60 lbs. with 125 volts on the terminals of the coil and with the plunger in the outer position. The stroke is from 2 to 3 in. These solenoids, of which there are four, are in series in a 500 volt circuit, and are fitted with dash-pots, which permit the weights to be lifted quickly, but only allow them to go down slowly.

The method of working will be understood by reference to Fig. 25, which shows the electrical connections. When the arms are at rest with both ends bolted, the switches in the red light circuit are all closed and the lamps are alight.

Passengers are then taken on. When the car at the end, say *X*, is full, the attendant at that end withdraws his bolt. This puts out the red light and so indicates to the attendant at the other end, *Y*, that he is ready, and also gives warning to the driver. Withdrawing the bolts also closes the switches in the solenoid circuit of the main switch, and closes the switches in the green light circuit at that end. One car being full, the attendant withdraws the bolt at that end. This action opens the red light switches so that the red lights cannot be relighted by closing the switches at the opposite end; it also closes the remaining switches in the main switch solenoid circuit so that this circuit is now closed except at the contacts in the controller, and it lights the green lights, so indicating to the attendant at, say *X*, that *Y* is unbolted and indicating to the driver that he can start. The driver then starts up and runs the trip, sighting arrangements being provided to enable him to bring the arms to rest at the right point.

Should an attendant, while the arms are in motion, improperly close one of the locking bolts the machinery will stop. Withdrawing the bolt will not restart the machinery. Should the machinery be stopped either by the improper movement of a bolt, by opening an emergency switch, by the driver overrunning and striking a limit switch, or by a temporary failure of the electric supply, the machinery can only be restarted by bringing the controller handle back to the off position and making a fresh start, and this of course can only be done by the driver.

It will be noted that when the controller is on the first step full voltage is put on to the terminals of the solenoid coil, and it must pull up the plunger with considerable force so as to bring the contacts together firmly. After passing the first step the controller introduces one of the resistances *i* or *k* into the solenoid circuit. The amount of resistance introduced must be such as to reduce the current to an amount which will still hold the plunger up firmly but will not be capable of pulling it up should it drop through a temporary stoppage of current, so that to pull up again the controller handle must be brought back to the first step. Thus full voltage cannot be thrown on to the motor should it be standing with no resistance in circuit.

(To be concluded.)

Workshop Practice

Rig for Boring Petrol Motor Cylinders in Pairs.—When the motor omnibus boom was at its height, about two years ago, our plant was taxed to its utmost capacity to keep up to guaranteed times of delivery with 30 h.p. four-cylinder petrol engines, for which we had a large contract.

The cylinders were cast in pairs, as shown marked *A*, in Fig. 1, and were bored on large turret lathes with a sliding fixture attached to the face plate, as is usual practice. Being desirous of getting the work through much quicker we designed the rig shown for boring two cylinders at the same time on a horizontal boring machine with a traversing table.

The cylinders were first milled on the bottom on a large vertical miller, they were then turned over and milled on the top for the water jacket cover. The castings were then taken to the boring machine and cramped on to the angle plate fixture *B*, which is cored out about ½ in. larger than the bore of the cylinders, and is cramped down securely on the traversing table by the four bolt holes shown.

The cylinders are cast with a hole cored through the water jacket on the top, central with each cylinder. This is found preferable to casting them with solid tops, as a support for the central core can be inserted to keep the latter in position, and a boring bar can also be passed through; these holes are tapped and plugged up when completed.

F is a cast iron ribbed bracket, shown in plan in Fig. 2, in front elevation in Fig. 3, and side elevation in Fig. 4. This is planed on the bottom and secured to the bed, or shears, of the boring machine, and not to the table. The two bosses at the top are bored out to receive the duplex boring spindles, *G* and *Q*, the centres of which are identical with those of the cylinders to be bored. *G* is coupled up with a cotter to the original boring-bar socket on the machine, and a solid pinion, *H*, is cut on it, which gears with another pinion *I*, which in turn drives the other spindle *Q*, with the solid pinion, *J*, cut on as shown. Both the boring bars revolve in the same direction by this method. *K* is a pin for securing the pinion *I*; *L* and *M* are two ball races for taking the end thrust of the boring bars; *N* and *O* are two nuts for securing the auxiliary bar *Q* in position; the four set screws *P* are for taking up the wear on the spindles and phosphor bronze split bushings by tightening down the two fibre strips, *R*, these being filed thinner for the purpose, as wear takes place.

The fixture is bolted down by the four bolt holes shown, and the two boring bars inserted in the sockets and passed through the cylinders into the end steady bushes *E*, as shown in position in Fig. 1. These bushings are split and supported by the cast iron bracket *C*. The two adjusting screws, *D*, are for tightening the bushes down on to the boring bars. This bracket is not bolted to the bed of the machine, but on to the traversing table, just behind the cylinders, thus giving a rigid support to the bars when at work.

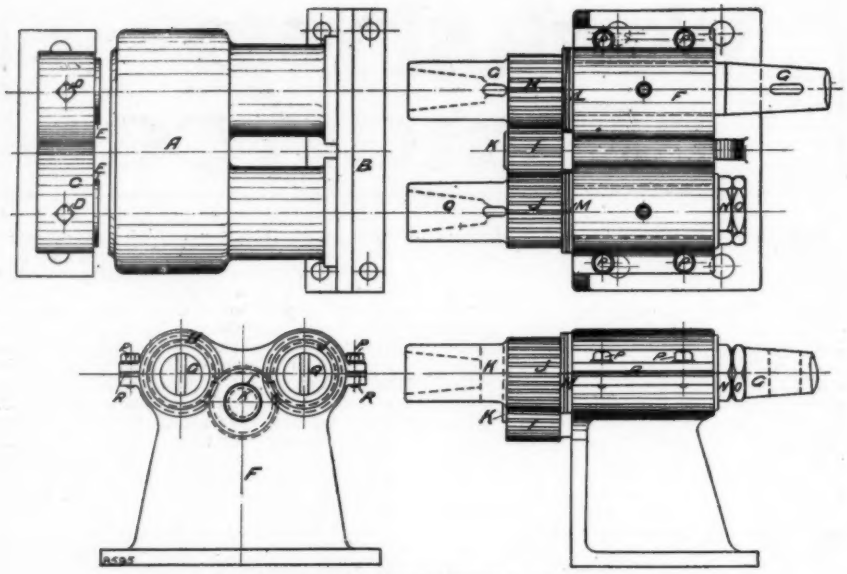
With this fixture we find that we can bore two cylinders, or a casting complete, in about the same time that it took us to bore one by our old methods, and the holes are spaced accurately in alignment, an important item.

When at work the pinions *H*, *I*, and *J*, are covered by a neat sheet steel guard to protect the operator and keep dust out of the gears.

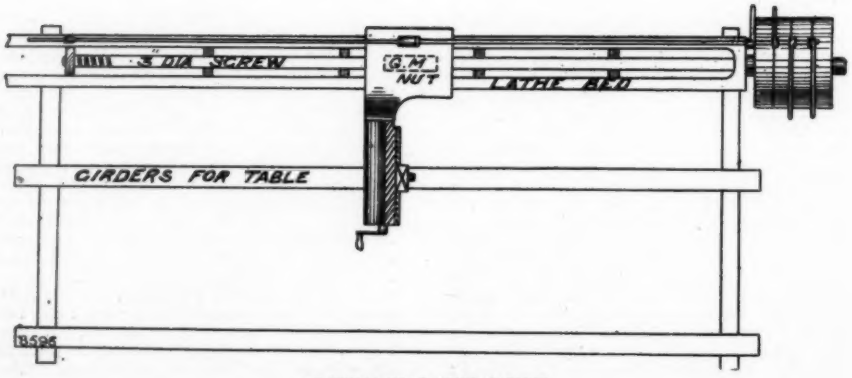
We have since made another of these fixtures, and keep the two constantly at work, to our entire satisfaction. S. L.

An Emergency Planing Machine.—Whilst in charge of an engineering works in the north, we had secured a contract to construct a plate steel storage oil tank for a Lancashire Corporation Gas Works. The tank was 72 ft. by 36 ft. by 6 ft. After the contract was signed we were notified that all plates and angles would require to be planed on all edges. This not being mentioned in the specification, we were allowed a certain price for the work over and above the original tender. The altered specification, however, involved us into some difficulties, as we had no such machine fit to perform the work in the place, the plates in some instances being 18 ft. by 6 ft., and the angles about 18 ft. in length. It was, however, important that we carried out the contract to the amended specification. As the price for the work would not admit of us purchasing a new side-planer especially for it, the following improvised machine was rigged up.

Amongst other machines in the works we



RIG FOR BORING PETROL MOTOR CYLINDERS IN PAIRS (FIGS. 1—4).



AN EMERGENCY PLANING MACHINE.

had a lathe with a 30-ft. bed, the width of the bed being 1 ft. 6 in. It was a lathe that was in constant use, but principally on short work, which left about 24 ft. of the bed not in use. The leading screw being at the back of the lathe did not interfere with the adaption of the bed to suit other requirements.

On looking through some of the local old machinery stores I came across a suitable square thread screw 3 in. diameter by 23 ft. long. I had one end of this turned down to a diameter of 2-in. to receive fast and loose pulleys; I then had it fixed between the bed of lathe, with the 2 in. end projecting, the other end being carried by brass bushes and fixed so as to bring the screw in true line with the bed. The screw was also supported on its underside by four brackets distributed throughout its length. I then had a gun metal nut cast on to a short piece of the screw which had been cut off: this when taken off I had split. A suitable means was thus provided of conveying power from the screw to the sliding head. From a neighbouring machine foundry I secured a pattern of a head with a front slide which fulfilled our requirements admirably. This we cast and fitted up, but in the place of an ordinary tool box I had fitted to the head an arrangement by which the tool would reverse and so cut both at right and left hand travel of the head.

The sliding head being fitted by the ordinary slides to the lathe bed and the gun metal nut being secured to the underside of the head so as to engage with screw, we proceeded to fix up pulleys and suitable striking gear.

There was nothing exceptional about the latter, it being on similar lines but in a modified form, to what is in use on high-class side-planers. A rod going the whole length of the bed, fixed above, and passing through an eye on the sliding head, with two sliding collars to regulate the travel of the machine. As soon as the sliding head came in contact with these collars, the rod would move in the direction of travel a sufficient distance to operate a lever with a counterbalance weight attached to the end of the rod, and which would carry the rod far enough through to cause the forks on the end of the same to shift the belt and so reverse the strike of machine.

The machine table was made up of 12 in. by 6 in. girders. Three were fixed to underside of lathe-bed, being supported at the front end by a block of concrete and the girders bolted thereto. The girders forming the table were bolted to the top of these, and when levelled formed a very rigid table. All plates were set out and the rivet holes drilled, the holes thus formed gave a good means of securing plates to the girders, the latter having been drilled beforehand to a similar pitch.

The cost of the improvised machine was small, and it did its work satisfactorily and at a cheap cost, and was kept in use after the completion of the contract which was the cause of its origin.

F. W. B.

The Industrial Uses of Ozone.*

A brief account was first given of the various methods for obtaining ozone, and of the different processes employed for water purification and sterilisation. The method used by Siemens & Halske was then described in detail. The apparatus consists of two concentric electrodes, the inside one being of aluminium and the outside one of glass. The aluminium one in order to keep it cool is hollow and has water circulating through it. The external one is also kept cool by water contact, and as the water is in an iron container which is earthed, this acts as a negative pole, and of course water is a conductor on the high tensions which are employed. Dried air is passed up the annular space between the two electrodes, and by means of the silent electric discharge which is there taking place, is ozonised. From the ozoniser the air passes up towers which are filled with pebbles, and over which the water trickles; by this means the water is divided up into a number of small streams, and consequently a very large surface is exposed to the action of the ozone. After the water has been thus treated it is allowed to flow into the reservoir in a series of cascades. By this means it comes in contact with the air, and any excess of ozone which may be in it is removed.

It is found that the water purified in this way becomes almost absolutely sterile, and any bacteria which may happen to remain are not of a pathogenic nature, consequently the water is absolutely safe for potable purposes.

The process can be very cheaply carried out, as it does not cost more than $\frac{1}{5}d.$ for every cubic meter of water which is treated. A portable plant has also been devised and is of particular use in case of war; in fact, some of them were employed in the late Russo-Japanese war. They should also be of value for other purposes—if the water supply of any town were to become contaminated with typhoid, for example.

The paper finally discusses other uses for ozone such as the oxidation of eugenol in the preparation of artificial vanilla and the bleaching and sterilisation of flour, a process used in a very large number of mills in this country. Flour so sterilised is capable of export for long distances, and may be kept for a very long time without deteriorating.

* Procs. Faraday Society, Abstract.

See Page 68 for Particulars of the SEVENTH WORKSHOP PRACTICE COMPETITION.

ELECTRICAL PROGRESS

By ANDREW STEWART, A.M.I.E.E.

Electrically Driven Rolling Mills.

No apology is necessary for returning to this subject. If any were necessary, the mere fact that there are at present some twenty-five rolling mill installations, and some thirty colliery winding plants projected, or in process of conversion in various parts of this country—several of the former, and all of the latter, using the "Ilgner" system of equalising the fluctuations of the load on the generating station—would supply that excuse for reverting to the subject.

Opinions may still differ as to the expediency of using electric driving for these purposes, under certain circumstances, but as the engineering problems to be faced are in some respects unique, and the method adopted to overcome the difficulty quite outside the range of the engineer's ordinary experience, no one questions the extraordinary interest that such plants excite. The outstanding feature, viz., economy of operation, was never, at any rate until recently, expected from the steam plant; all that one might reasonably expect was that it should run without breaking down. The economies achieved in several cases, when electric driving has been introduced, must be attributed in all fairness, quite as much to the fact that the modern electrical plant superseded an out-of-date steam equipment, as to the inherent economy of electric driving.

In recent years makers of steam equipments have devoted much attention to this question, and no one will deny that they now produce reasonably economical mill engines. Such achievements will exert little influence on the progress of the electrically driven mill, for owners when sinking fresh capital in their works will no doubt prefer to be quite up-to-date, and for that reason the achievement of the steam engineer should not be regarded with apprehension by electrical men, but will no doubt serve as an incentive to fresh effort.

The chief reason for returning to the subject of mill driving is the very complete paper read by Mr. W. Edgar Reed, to the Engineers' Society of Western Pennsylvania, U.S.A., on "Electric Power in Steel and Iron Mills." After dealing with the general question of electric power, in terms which have been specified in this section on many occasions, he proceeds to deal specifically with the driving of heavy mills.

In order to make the problem clear the author gives curves, one of which, relating to a 30-in. reversible mill, we reproduce, Fig. 1. This gives graphically all the data one wants as to the performance of these, while Fig. 2 gives the general lay-out of a reversing mill. It will be seen that the roll-motors are housed outside the mill proper, and that the motor generator or equaliser set is housed along with it.

One reason why two motors are used for driving the mill is that the diameter of the rotating mass, and therefore the kinetic energy stored therein is reduced, and the set is brought to rest more rapidly than would be the case if the driving unit was one large motor.

The general features of the fly-wheel converter, or motor generator, are, of course, well known, having been dealt with from time to time in this section; one feature of interest, however, emerged during the discussion on Mr. Reed's paper, viz., that while, as our readers know, the heavy cast-steel fly-wheel is in common use in this country and in Europe, the tendency in the United States is to use a laminated wheel. One installation was referred to where a fly-wheel converter had two 45-ton wheels running with a peripheral velocity of 16,000 ft. per minute. The hub is a steel casting, but the rim is made up of sheet steel punchings, about No. 22 gauge. These are assembled overlapping, and dovetailed into the arms of the spider. Heavy end

plates serve to clamp the sides of the rim together by means of bolts passing right through the stampings, and it is stated that the friction between the stampings, apart altogether from the dovetailing, is sufficient to withstand twice the centrifugal force to which they are subjected. These wheels are stated to be safer than a cast-steel fly-wheel of the same diameter, a statement not difficult to appreciate when one considers the difficulty in casting such large wheels without weakening due to cooling strains, or the development of latent flaws when in operation.

The fly-wheel effect of the laminated wheel just described is (weight in lbs. × radius of gyration in feet^2) 2,600,000, and a decrease of about 24 per cent. in its speed would cause it to give up about 45 per cent. of its kinetic energy.

The author gave particulars of the 30-in. plate mill at the works of the Illinois Steel Works, which, it appears, is driven by two 2,000 h.p. direct-current shunt-wound motors mounted on a common shaft just as shown in Fig. 2. The speed varies from zero to 150 r.p.m., and the mill is capable of reversing every four to six seconds. Good

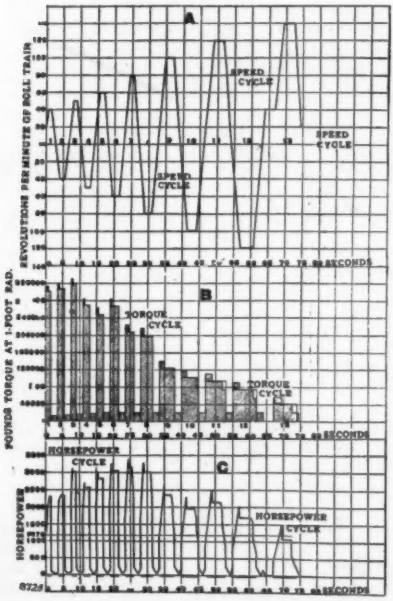


FIG. 1.—SPEED, TORQUE AND HORSE-POWER CURVES, SHOWING REQUIREMENTS OF 30-IN. REVERSIBLE MILL.

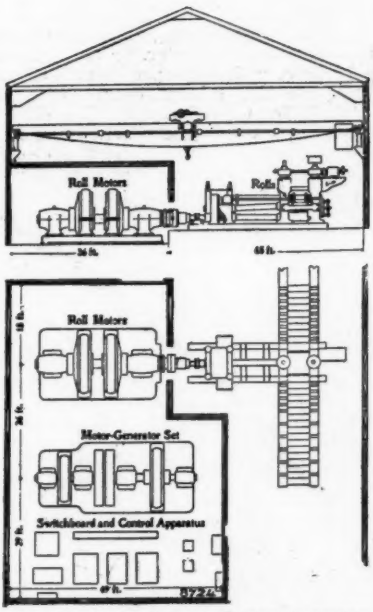


FIG. 2.—ARRANGEMENT OF ELECTRICALLY-OPERATED MILL AND CONVERTER.

commutation is ensured by commutating poles, and also by compensating coils wound in slots in the face of the magnet poles. The power taken from the generating station by the converter is only 30 per cent. of the maximum load on the mill motor.

An 8,000 H.P. Turbo-Alternator.

The largest "Parsons" type steam turbine for land work, so far built in England, has just recently been completed and erected in the Stuart Street Station of the Manchester Corporation Electricity Works. It is coupled direct to a three-phase alternator, capable of giving an output of 6,000 kw., at a pressure of 6,500 volts when running at 1,000 r.p.m. The turbine is by Messrs. Willans & Robinson, and is chiefly remarkable for its short overall length, being 36 ft. long, while the complete set, turbine and generator, is 46 ft. 3 in. long. The high-pressure chamber is 34 in. diam., the intermediate 51 in., and the low-pressure 77½ in. The turbine shaft is 11 in. diam. and the rotating part weighs 13 tons.

The complete turbo-alternator weighs

158½ tons, and is illustrated—Fig. 3. A feature of this generating unit is the method of cooling the alternator. As our readers are aware, with high-speed electric generating plant, the large output which is obtained from a relatively small electric generator, involves the generation of heat due to the internal magnetic and electric losses, much in excess of that which can be readily radiated from the relatively small area exposed to the atmosphere. It is therefore necessary to make some provision for the radiation of this heat. In some turbo-generators this is effected by water cooling, the circulating water being carried through the stator, or armature, in pipes. In the case of the machine under consideration, a motor-driven Sirocco fan, capable of delivering 21,000 cub. ft. of air per minute, is installed in a fan room just outside the engine room, and the air, which is first filtered through wool screens, is then delivered into the centre of the stator casing and then through the armature and around the field magnet, out to the atmosphere by an exhaust shaft.

The generator, which is by Siemens Dynamo Works, Stafford, is, as will be clear from Fig. 3, totally enclosed, and will carry a 15 per cent. overload continuously, and a 25 per cent. overload for 1½ to 2 hours, or 50 per cent. overload for 15 minutes.

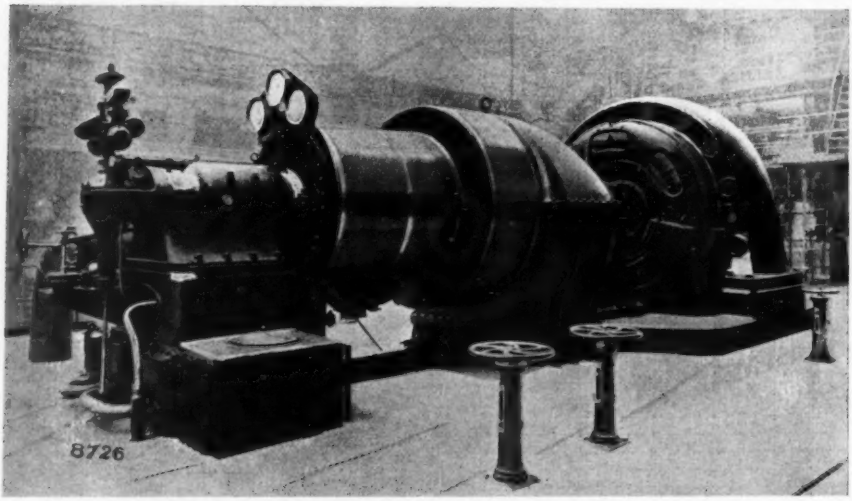


FIG. 3.—6,000 KW. TURBO-GENERATOR, MANCHESTER CORPORATION ELECTRICITY WORKS.

A 100,000 H.P. Electric Generating Station.

A decade ago any one daring enough to suggest an electric supply station of 100,000 h.p. capacity would have been considered lacking in judgment, if not in mental balance, for the more modest generating stations of the period were considered large at a fraction of the size, and the expediency of dividing the generating plant among two or more stations located in different parts of the district to be supplied, was unquestioned. To-day no engineer hesitates to put all his eggs in one basket, and a large number of eggs in that. One of the largest undertakings of this kind is the Fisk Street station of the Chicago Edison Co.

As originally laid out, the station was designed to accommodate fourteen "Curtis" turbo-alternators, each of 5,000 kw. It was found, however, that owing to improvements in design, the last units could be rated at 8,000 kw., and this was done, hence the capacity of the station when completed is 100,000 kw.

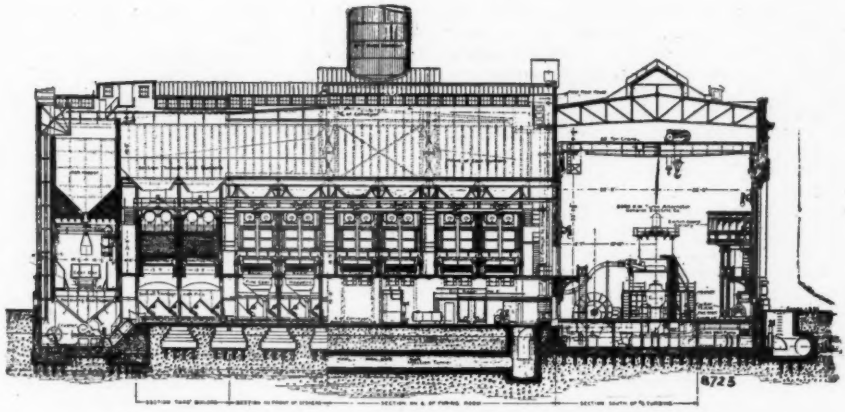
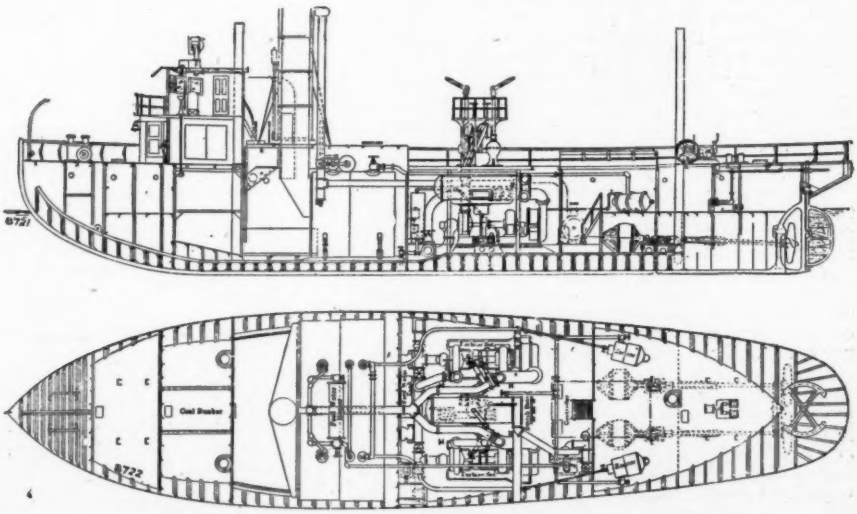


FIG. 4.—CROSS-SECTION OF FISK STREET POWER STATION, CHICAGO EDISON COMPANY.

The generators are, in four cases, 7,000 h.p. "Curtis" vertical turbo-generators, and in six cases 11,500 h.p. sets. It will be seen, therefore, that these later units are somewhat larger than the new "Parsons" turbo-alternator at Manchester, described in a preceding paragraph; but of course, "Parsons" turbines have been built much larger than anything else for marine purposes. The speed of these large generators is in the case of the 5,000 kw. sets 500 r.p.m., and in the case of the later units 750 revs. The steam turbines in the first units were two-stage machines with three steam chests, each with twelve nozzles. The fourth unit had its stages increased to four with two steam chests and fifteen nozzles. The latest have five stages, but are otherwise similar. The early turbines were fitted with electrical control, but the recent turbines have the



FIGS. 5 AND 6.—DETAILS OF ELECTRICALLY PROPELLED FIRE BOAT.

valves operated by hydraulic means, as it gives positive action. The boiler plant is by Babcock & Wilcox, and the general arrangement is shown in Fig. 4, where the boilers are arranged at right angles to the turbine room. This arrangement has been adopted in several recent steam turbine stations because of the small amount of ground space occupied by the steam consuming, as distinguished from the steam generating plant. It is interesting to note (*inter alia*) that the general arrangement of this station, including the location and type of the turbo-generators, is similar in many respects to the proposed power station of the London and District Electricity Supply Bill, now being considered by a committee of the House of Lords.

Electrically-Propelled Fire-Boats.

The fire department of the city of Chicago have nearly completed two fire-boats which are unique in many respects. The vessels are 120 ft. over all, 28 ft. beam, and draw about 9 ft. 6 in., constructed of steel throughout. The forefoot is cut away as shown (Fig. 5) in order that the vessel may break its way through ice. A feature of considerable interest is the method of mooring the vessels. It is difficult to moor such a vessel when operating at a fire, so the boat is fitted with three poles of steel pipe. There are two forward, and one aft, and whenever it is desired to moor the vessel these are driven down into the bottom of the channel where they hold securely in the river bed. The location of the two forward poles will be seen beside the coal bunker on the plan (Fig. 6).

The steam generating plant consists of two Scotch boilers, and in the engine or, more correctly speaking, pump-room, there are two horizontal "Curtis" steam turbines of 660 h.p. each, coupled direct to 14-in. two-stage centrifugal pumps, which are capable of delivering together 9,000 gallons of water per minute, at a pressure of 150 lbs. per sq. in. By a suitable arrangement of pipes one pump may discharge into the suction of the other, *i.e.*, may be put in series, in which case the pressures will be 300 lbs. per sq. in. and the discharge 4,500 gallons per minute. The advantage of centrifugal pumps is that the volume and capacity are under complete control, and should all outlets be closed, the pressure rises only a small amount, while, with reciprocating pumps, damage would result to the piping.

In addition to these centrifugal pumps there are 200 kw. generators coupled to each steam turbine; these generators operate the auxiliary machinery, and also supply current to two variable speed reversing motors of 250 h.p. each, driving the propellers (see plan, Fig. 6). The advantage of the motor drive is that absolute care and certainty of control is obtained from the navigating bridge. The motors, moreover, will not race when the propellers are out of the water in a rough sea.

The discharge nozzles are located amidships on a deck turret. These turrets are heated by steam during the winter to prevent the discharge pipes freezing.

The Scleroscope.

The scleroscope is an instrument devised by Mr. Albert F. Shore, with the assistance of Dr. Paul Herould, to measure the hardness of metals. It consists in essence of a glass tube, within which a steel ball of 40 grains weight, treated by a special process so as to have jewel hardness, falls freely. The height of the rebound of the ball measures the hardness of the metal it strikes. Were the area of contact between the dropped weight and metal larger, so that no appreciable dent were made, the rebound would be a measure of elasticity rather than hardness. The height of the rebound is measured on a scale, of which 100 is the average hardness of carbon steel, which is also found to be the safety limit for steel tools after reheating and tempering ready for use. Mr. Shore states that the instrument will be found very useful in the manufacture of tools like twist drills, where the hardness has to be kept between narrow limits. An interesting booklet giving full particulars of the apparatus is issued by Messrs. Schuchardt and Schutte, 34, Victoria Street, S.W., who are the sole agents in this country.

The "Unitas" Calculating Machine.—In describing this machine on pages 417-8 in our last issue we inadvertently stated that it was being exploited by the "Pin and Unitas Calculating Machine Co., 105-6, New Bond Street, W." For the word "*Pin*" read Tim.

Iron, Steel and the Foundry.

Conducted by PERCY LONGMUIR.

STEEL: ITS PROPERTIES AND TREATMENT.

Factors of Safety in Marine Engineering. — Professor Arnold, in an important paper read before the Institution of Naval Architects, gives the engineer and steel-maker much food for thought in reference to alleged factors of safety. As a whole the paper may be rather disconcerting to the steel-maker; it is, however, most timely and full of suggestive matter demanding careful attention.

In general, calculations are based on the maximum stress capable of being endured by the metal employed, for the reason that:—(1) Maximum stress is a value capable of accurate and rapid measurement; (2) it is a more or less accepted canon in engineering faith that the maximum stress is really an indirect measurement of the elastic limit in the ratio of about two to one. This rule is approximately true, but it is also equally true that in a relatively small but none the less important number of instances this widely accepted datum is inaccurate. After examining rules followed in calculating factors of safety, the author passes on to a consideration of the true elastic limit. Experience has shown that the difference between the yield point and the true elastic limit in normal structural steels is about $1\frac{1}{4}$, and in over-annealed steels about $3\frac{1}{2}$ tons per sq. in. The following result from a steel casting, published by the author some ten years ago, has a very direct bearing.

Condition of steel.	Elastic limit. Tons per sq. in.	Maximum stress. Tons per sq. in.	Elongation per cent. on 2 in.	Reduction of area per cent.	Bending tests.
As cast...	17·6	25·5	5·0	5·6	21° broken.
Annealed	7·4	24·3	32·5	37·7	180° unbroken.

This casting contained 0·4 per cent. carbon, 0·26 per cent. silicon, and 0·10 per cent. manganese, with low sulphur and phosphorus. The figures 7·4 have reference to the yield point, hence the true elastic limit of this material was really approximately 3·9 tons per sq. in. An elastic limit so low as about four tons per sq. in. justifies the author in putting forward as a tentative hypothesis that mild steel by over-annealing may actually, like pure copper, have practically *no elastic limit*. In other words, at any point above the zero of a stress strain diagram the metal may assume plastic as distinct from elastic deformation. In such a case the factor of safety must be, theoretically, almost indefinitely great to prevent the ultimate fracture of the steel.

Turning to the failure of factor of safety calculations noted in actual practice the author gives a typical example by taking the mean result of several cases. This average case includes about twenty careful determinations each of the maximum stress and elastic limit of the steels involved, which were for the most part in the form of hollow shafts, ranging between 22 in. and 25 in. diameter. The mean static results of the "pooled" tests are as follows:—

True elastic limit. Tons per sq. in.	Maximum stress. Tons per sq. in.	Elongation per cent. on 2 in.	Reduction of area per cent.
8·5	28·5	30·5	52·5

All the shafts involved had evidently been over-annealed, not necessarily in the sense that they had been overheated, but rather that they had been kept for too long a time in a low red range of temperature. It is probable that in designing these shafts the material was supposed to have a maximum stress of 30 tons per sq. in., and that the factor of safety was to be say 7 to 1, this is equivalent to a working stress of about

4·3 tons per sq. in. Intention and achievement are shown in the following table:—

Factor of safety calculated on assumed maximum stress.	Factor of safety calculated on actual maximum stress.	Factor of safety calculated on assumed elastic limit.	Factor of safety calculated on actual elastic limit.
7·0 Adequate.	6·65 Adequate.	3·5 Adequate.	1·9 Quite inadequate.

The shafts of which the above mean table is typical all fractured in use, and the result in the last column distinctly understates the worst case.

In discussing dynamic testing in its bearing on factors of safety, the author gives first a clear *resumé* of Wöhler's researches. This is followed by a description of the author's alternating test,* devised in 1905, in order to bring Wöhler's method into practical works use by reducing the time of testing from hours to seconds. The accumulation of tests by both methods have shown the Wöhler to be merely a reflection of the elastic limit, and whilst it indicates danger of fracture under excessive stresses, it does not indicate danger from other causes which determine fractures generally attributed to fatigue. In fact, no matter how dangerously brittle the steel may be, from chemical or physical causes, if such causes have co-produced a high elastic limit, the Wöhler tests indicates the steel to be quite safe if stressed well short of that limit, when as a matter of fact, it is inevitable that the steel must suddenly rupture sooner or later under stresses theoretically safe. By way of illustration two comparative series of tests are given, in which the Wöhler result shows that a mild steel of 0·5 per cent. phosphorus was with equal stresses ten times as capable of resisting alternating stress as the same steel containing only 0·04 per cent. phosphorus. Professor Arnold's tests of the same steels showed that the steel of 0·5 per cent. phosphorus possessed about one-third the endurance of the 0·04 per cent. phosphorus steel.

Experience has shown that high elastic limit does not necessarily make for safety. Any metal subjected to a working stress not far removed from its elastic limit must inevitably fracture as the result of a complex final cause, of which the Wöhler phenomenon is the most important factor; but it is a great mistake to suppose that because a steel of high elastic limit gives a good result under the Wöhler test it will be, therefore, faithful in practice. The phosphorus steels quoted above show that the Wöhler test failed to detect their brittleness, and had such steels gone into use sudden fracture would certainly have occurred. As another example cold working has been practised to a considerable extent in order to raise the elastic limit. Cold drawn bolts give high elastic limit and excellent Wöhler test results, but in practice these bolts are excessively dangerous. This statement is supported by a number of tests which go to prove that an artificial raising of elastic limit, as by cold work, gives a steel very prone to sudden fracture under the alternation of stress.

* Previously noted in this section.

The Practical Application of Vanadium to Steel and Iron.—In a recent issue of the *Iron Trade Review*, Mr. J. Kent Smith details some of the beneficial influences of vanadium when added to steel. These features have been fully noted in this section, but some advice is also offered as to the method of adding vanadium, and of this we note the following:—

Crucible Process.—Charge as usual, adding any chromium or nickel required with the initial charge. When the steel is "killed" the vanadium alloy is introduced with such extra ferro-manganese as the circumstances of the case may dictate. In from twenty to thirty minutes the crucibles are drawn and poured as usual.

Acid Open Hearth.—The charge is worked down as usual and at the finish the slag should be supersilicated, that is it should contain at least 52 per cent. silica and should not contain excess of oxides of iron and manganese. Silicon pig warmed on the breast of the furnace, and any necessary ferro-chrome are next added and a few minutes later the ferro-manganese. The flame is then blanketed and the vanadium alloy added in large pieces; three minutes will suffice for its working through the bath, which in the meantime is rabbled. Tapping and teeming are performed as usual.

Basic Open Hearth. — The charge is melted and worked down to about 0·4 per cent. carbon and then "shaken down" to decarburisation. The slag should be in good condition and free from excess of metallic oxides. Ferro-chrome is charged making due allowance for loss, thus in good practice a charge of 1·3 per cent. chromium would give 1 per cent. chromium in the resulting steel. It may be necessary to follow this addition with a little fluor-spar in order to keep the slag sufficiently open. Ferro-manganese is then added in lump

form to the bath, and when the additions are incorporated the furnace is tapped. After a small quantity of steel has run into the ladle, ferro-vanadium and any further high grade ferro-silicon required are added, the additions being completed before slag appears. Ladle additions are broken into small pieces and preferably preheated.

Bessemer and Tropenas Practice.—Ferro-vanadium is added to the ladle as in basic practice. Nickel would be added with the charge and chromium before or with the deoxidents.

The actual loss of vanadium cannot be definitely stated owing to the variable amount used up in cleaning the metal. From an average of many acid charges, taking precautions to secure as far as possible a deoxidised bath, the loss amounted to about 10 per cent., a portion of this lost vanadium having been used up in doing useful work. Analysis of the slags showed them to contain from 0·26 to 0·30 per cent. vanadium, which taking into account the proportions of slag, metal and vanadium used substantially bears out the loss figure given. In basic practice the loss is necessarily somewhat higher and will approximate between 15 and 20 per cent., partly on account of the greater proneness of basic metal to retain oxides in solution.

FOUNDRY PRACTICE.

Converter or Small Open Hearth.*—In his fourth instalment, Mr. W. M. Carr summarises the disadvantages of the open hearth, and among other features the following are noted. As compared with the converter the open hearth is costly to instal and it is also costly to repair. In comparison with the converter the open hearth is slow as a producer. Under normal conditions, and with any size charge, the shortest time is about six hours per heat. The converter will blow a heat in half an hour, so that concerning the question of speed the converter holds the ground. The open hearth is not suited for irregular production, and the highest economy can only be reached by continuous operation. A converter can be heated up during the morning in readiness to blow in the afternoon, and like the open hearth its first heat will not be so hot as succeeding ones, but no matter whether running a converter or open hearth, one heat per day would be poor practice, since it is apparent that the costs will be heavy when divided among a few tons.

* The *Foundry*.

Annealing Steel Castings.—In a recent issue of the *Foundry*, Mr. E. H. Ochler deals with the annealing of steel castings, the two fold object being to relieve casting strains and to obtain the best possible physical structure in the metal. In regard to the first, little attention need be given to the annealing temperature. To attain the second object some attention must be paid to temperature, which, however, for practical purposes is not very limited in range. The structure of the steel will at once show if the steel has been seriously overheated or under-heated. Even the fracture of the steel will give some information; thus the grain will not be fine unless the metal has been heated above the critical point. In regard to overheating fracture alone will not convey much information. The grain will not be fine unless the metal has been heated above the critical point. Steel containing from 0·20 to 0·30 per cent. carbon should be heated to the neighbourhood of 8·30° C. in order to obtain good results. The writer quotes cases in which he has noticed a coarse crystallisation associated with a fairly good micro-structure, the cause being due to prolonged heating at too low a temperature.

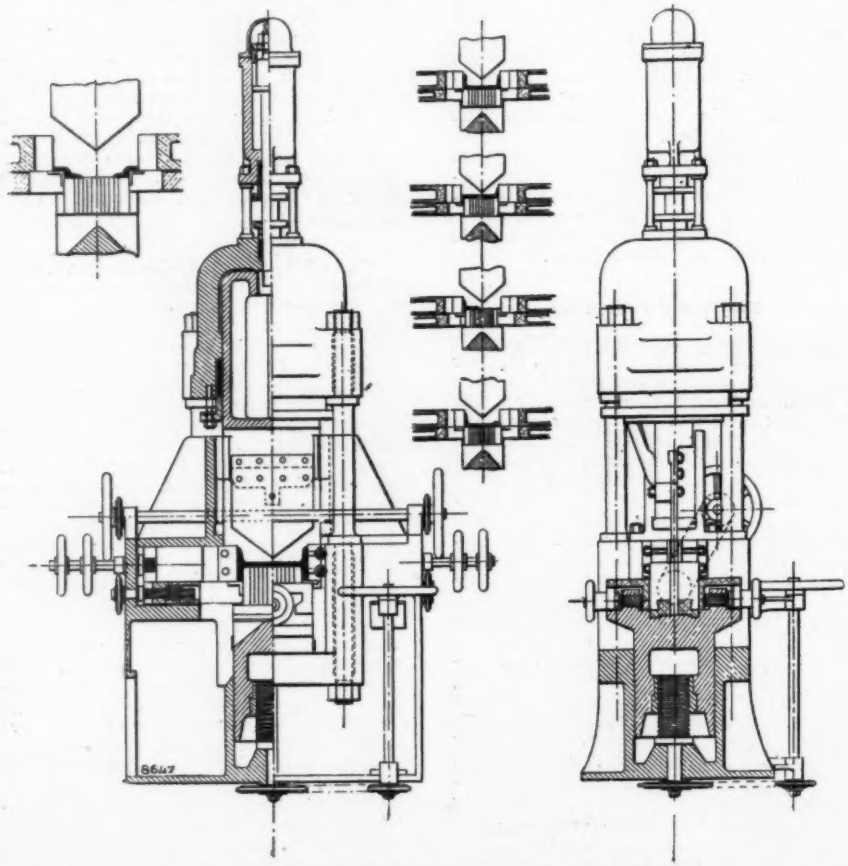
Vanadium in Cast-Iron.—Mr. J. Kent Smith states in the *Iron Trade Review* that the benefits accruing from the judicious addition of vanadium are great, although not so spectacular in their nature as those which are conferred on steel. Strength, rigidity and resistance to wear are increased by the addition of vanadium to grey iron, and it is also noted that chilled rolls containing vanadium have shown a remarkable increased resistance to wear in service. The addition of vanadium to air furnace metal is comparatively simple. When the charge is melted, then the vanadium alloy and the metal is well rabbled at intervals during the twenty minutes or half hour which intervenes before pouring. With cupola metal vanadium, owing to its ready oxidability cannot be added to the charge, and the ordinary alloy when added solid does not readily dissolve in the ladle. One method of using the ordinary alloy is to place it in powder form on the bottom of a crucible and pour on to this about five times its weight of molten cast-iron, the crucible then being heated for about half an hour. This mixture is poured into the ladle and the contents well rabbled. Vanadium may be readily added in the solid in the form of ferro-silico vanadium which is readily taken up by molten cast-iron. This

alloy is pulverised and added with about 0·3 per cent. ferro-manganese direct to the molten stream of iron as it leaves the cupola spout.

Foundry Waste.—Taking as his text "waste means want," Dr. Moldenke in a paper to the Chicago Foundry Foremen's Association enters into many of the economical opportunities offered in the foundry. The items discussed include recovery of iron; saving in core making; arrangement of plant; moulding sands and moulding machines.

Throughout the general tone is attention to detail and the application of existing knowledge. In regard to cupola practice Dr. Moldenke's remarks are very much to the point. "Now in cupola practice saving is in most cases waste" is a truism that many British founders have personally experienced. Attempts at high melting ratios are strongly deprecated and the few pounds of coke saved always mean trouble in other directions. As long as the first iron shows from seven to ten minutes after the blast is put on, and the iron does not come too slow or too hot at the end, it is better not to tamper with the coke ratio of the cupola in question.

Similarly to attempt to save 25 cents a ton in the mixture and at the same time increase the percentage of discards or the cost of machinery is a waste.



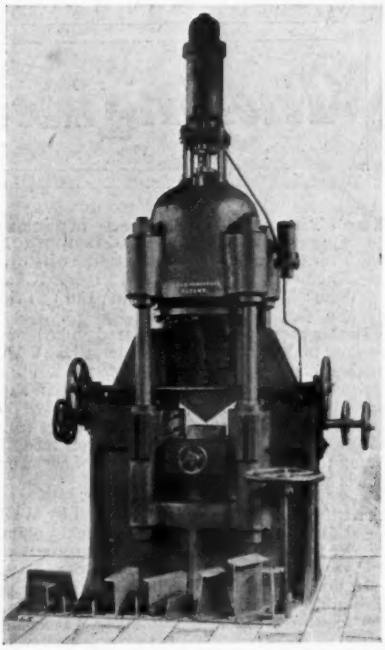
HYDRAULIC BAR SECTION SHEARING MACHINE. (*See next page.*)

Hydraulic Section Bar Shearing Machine.

The illustration below, and that on the preceding page, are those of a hydraulic section bar shearing machine specially adapted for shearing joists, channels, zeds, bulb angles, tees, angles, and other sections, right or left hand, and either square or to any angle up to 18 degs. without distortion. The machine is capable of shearing any size of joist up to 16 in. deep, and any size of zed, channel, or bulb angle bar up to 15 in. deep, angle bars up to 8 by 6 by 1 in., and standard sizes of tee bars by adjustment of blades.

The bars to be sheared are supported externally on three sides by double blades, and the top blade attached to the large slide forms a punch, cutting a piece completely out of the bar about 1¼ in. thick and the full width, leaving both sides of the bar free from distortion. The bottom blades are made up in book form, and firmly clamped together from two sides, forming a solid block; and to ensure of the blades being perfectly in line, they are checked underneath, and this check fits into a corresponding check on the machine. The blades are also clamped from behind by adjustable slides. A few of the bottom blades are made of various thicknesses, and these bottom blades can be taken out or put in quickly, as required, when the section of joist or zed bar to be sheared is larger or smaller than that being operated on. All sections of channel, bulb angle, tee, and angle bars can be sheared without changing any blades. The side knives are adjustable horizontally from both sides to suit the various widths of bars, and the bottom blades are adjustable vertically to suit bars with various depths of flanges.

The line drawing shows how the machine is adjusted to accommodate the various shaped sections.



HYDRAULIC SECTION BAR SHEARING MACHINE.

The body of the machine is made very strong of cast iron, and the main hydraulic cylinder is supported by four mild steel columns. A drawback cylinder is fitted on top of the main hydraulic cylinder for raising the shearing slide after the bar has been cut.

The machine is manufactured by Messrs. Smith Bros. & Co., Kinning Park, Glasgow, to whom we are indebted for the foregoing particulars.

Manufacturers are invited to send advance particulars, drawings and photographs of new machinery or installations possessing special features of interest, to the Editor, *E.R.*, 104, High Holborn, W.C.

The Engineer's Book-shelf

The Theory of Arched Masonry Dams. By Capt. A. Ff. Garrett, R.E. Professional Papers of the Corps of Royal Engineers. (Fourth series.) 1908. (Chatham: W. & J. Mackay & Co., Ltd.) Price **1s. 6d.** net.

In this paper what is considered to be a new method of dam construction is described. The method consists in breaking up a dam into a series of horizontal arches of short span supported by suitable piers, the convex faces of the arches facing upstream. An economy of from 16 to 39 per cent. in masonry claimed, is stated to be effected when this type of construction is adopted.

Practical Coal-Mining. Edited by W. S. Boulton, B.Sc., F.G.S. Divisional Volume V. (London: The Gresham Publishing Co., 34, Southampton St., W.C.). Pp. x. + 176.

In this volume, forming the fifth of the series, the subjects dealt with are "Lighting," by Jas. Ashworth, M.I.M.E.; "Colliery Explosions and Rescue Appliances," by W. Galloway, F.G.S.; "Mineral Holdings," by H. F. Bulman, A.M.Inst.C.E., M.I.M.E.; and "Mine Surveying," by L. H. Cooke, A.R.S.M. The standard of excellence in text, printing and illustrations is well sustained, and colliery managers and engineers should find the series of much practical value, presenting as it does a concise, at the same time fairly full, treatment of modern apparatus and practice.

Manual of Re-inforced Concrete and Concrete Block Construction. By C. F. Marsh, M.Inst.C.E., and Wm. Dunn, F.R.I.B.A. (London: Archibald Constable & Co., Ltd., 10, Orange St., W.C.). Price **7s. 6d.** net. Pp. vii. + 290.

The prominence into which the method of construction in re-inforced concrete has sprung, naturally suggests the question as to what literature is available on the subject. Most of the information afforded has, up to the present, been scattered throughout the technical press in the proceedings of engineering societies, hence the appearance of this handbook giving, in compact form, the necessary data required in the design, construction or supervision of work of this class, will be welcomed by those interested in this method of erection. Many useful tables and diagrams are given, showing at a glance the safe superload on slabs, spans and re-inforcements; data for obtaining pressures, &c., on retaining walls, bins and silos, and other information; and numerous other features assure for the volume a welcome reception.

Le Problème de L'Aviation: sa Solution par L'Aeroplane. By M. Armengande. (Paris: Librairie Ch. Delagrave, 15, Rue Soufflot.) Price **2fr. 50.**

This work contains a historical summary and an exposition of the present state of the question. In connection with the latter, the author deals fully with the experiments conducted by Lebris, Lilienthal, Pilcher, Santos Dumont, &c., and afterwards considers the theoretical aspect of the problem of aviation. Two interesting tables conclude the volume, one giving schematic diagrams of the various forms of aeroplanes proposed and tried; the other formulæ applicable in construction.

Those interested will find the work at once useful and readable.

First Stage Steam. By J. W. Hayward, M.Sc. A.M.I.Mech.E. Second Edition. (London: W. B. Clive, University Tutorial Press, Ltd., 157, Drury Lane, W.C.). Pp. xv. + 247.

Although this work has been primarily designed to cover the syllabus of the Board of Education for the first stage examination in "Steam," we can, after having thoroughly tested it, cordially recommend its use by all beginners in this subject.

The author has spared no pains to render his text lucid and his explanations and examples complete, while the simple experiments suggested by him capable of being carried out with simple home-made apparatus, will be found of value to those students who read the book without possessing laboratory facilities. A further feature of the work is the treatment accorded to steam turbines and internal combustion engines.

In this section is presented every month a list of the more important articles appearing in the Engineering Press and of the leading papers read before the various engineering institutions. Full names, addresses, and published prices of the publications indexed are printed each half-year in the volume index.

Civil Engineering.

The Stresses in Masonry Dams. *Engineering*, 22*nd May*, 1908.

Structural Steel Work, VIII., IX. *Mechanical World*, 22*nd May*, and 5*th June*, 1908.

Comparative Costs of Earthwork. By A. P. Davis. *Engineering Record*, 16*th May*, 1908.

A Light Three-Hinged Concrete Arch Bridge in Rock Creek Park, Washington, D. C. *Engineering News*, 21*st May*, 1908.

Coast Erosion. By Dr. J. S. Owens. *Engineer*, 15*th May*, 1908.

Roofs, VIII. *Railway Engineer*, *June*, 1908.

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SIXTH WORKSHOP PRACTICE PRIZE COMPETITION.

AWARD OF PRIZES.

The four prizes offered for the sixth competition, which closed on June 15th last, have been awarded as under:—

PRIZE OF £4.

MR. J. GREEN,
Pershore Road,
Birmingham.

PRIZE OF £1

to each of the following:—

MR. W. RIDLEY, 17, Duckworth Street, Stoke, Devonport.

MR. JOHN T. PAGON, 20, Garnett Avenue, Liverpool.

MR. F. G. WILLIAMS, "Bankside," Worting Road, Basingstoke.

The prize articles will be printed in the next issue.

SEVENTH COMPETITION.

We again offer four prizes—one of £4 and three of £1—for the best short article describing and illustrating any emergency device or job that has taxed the ingenuity of those in charge of machine tools, or who are engaged in fitting or erecting.

INSTRUCTIONS AND CONDITIONS.

Articles must be written on one side of the paper only, and be signed by the competitor.

Drawings and sketches must be on separate sheets of paper.

A short biographical sketch of the competitor's technical experience must accompany the article.

The right is reserved of publishing the prize articles, and also any of the others sent in; but in the case of the latter, payment will be made for the same at our usual scale rates.

The Editor's decision in all matters connected with the competitions shall be final, and binding on all the competitors.

All articles should be addressed to the Editor of THE ENGINEERING REVIEW, 104, High Holborn, London, W.C., and marked on the outside, "Competition," and the same must be received not later than September 5th.